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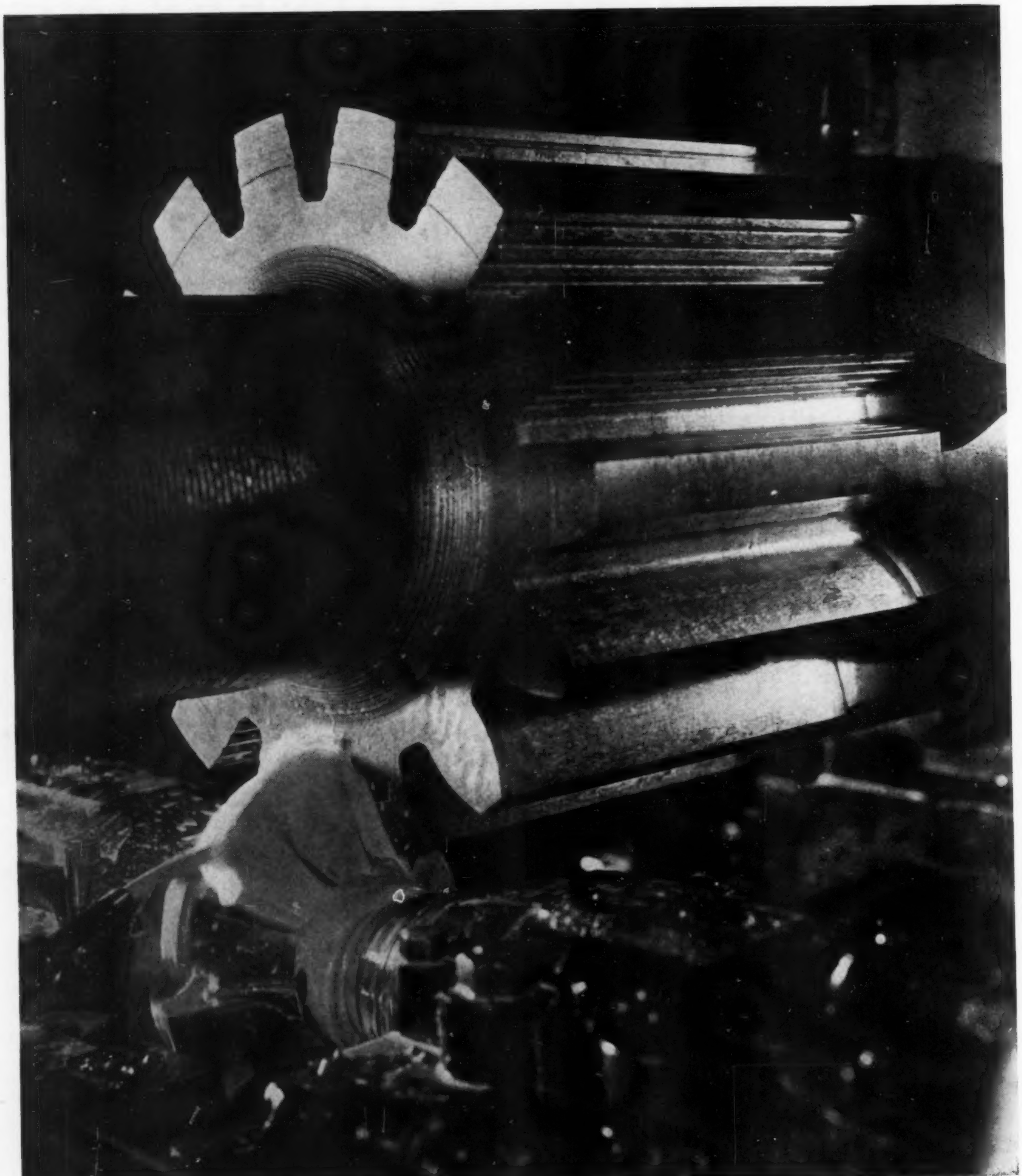

Young and Phelps

Cutting a Pinion Integral With Its Shaft

VOLUME 59
No. 4

MECHANICAL ENGINEERING

APRIL
1937

GEORGE A. STETSON, *Editor*

On A.S.M.E. Business

ON PAGE 307 of this issue is presented the itinerary of the southern and western trip which the secretary of The American Society of Mechanical Engineers is making on behalf of the Society. Members in the sections of the country that lie along Mr. Davies' route will have an opportunity to meet him, if they have not already done so, to hear from him about some of the work in which the Society is engaged, and to lay before him their own views and suggestions on Society problems. Because of the wide extent of the Society's membership, the opportunity of this close personal contact made possible by the Secretary's visit cannot come as frequently as may be desired and hence there is all the more reason why advantage should be taken of it when it is available.

Mr. Davies' trip is happily timed immediately prior to the 1937 Semi-Annual Meeting at Detroit in May. The Secretary will thus be able to present to the Council, which meets at Detroit, his personal observations and whatever pressing matters of Society policy and business result from his visits and conversations.

No one is more sincerely concerned with the welfare of the Society and its members than the Secretary. His viewpoint is and must be national. His acquaintanceship must include every student branch and local section, and as many individual members as he can reach or can reach him. All members of the Society can increase the effectiveness of his administration of its affairs by stating their views and problems to him frankly.

Publicizing the A.E.C.

FOR many months excerpts from the newsletter of the American Engineering Council have been published in the A.S.M.E. News section of MECHANICAL ENGINEERING under the heading "A.E.C. News From Washington."

At a recent meeting of the Publicity Committee of the A.E.C. this news service which the Council supplies to the engineering societies was discussed, and the suggestion was made that the several items of news which the newsletter contains might receive wider attention if they appeared as separate notes with appropriate headings instead of being placed together under a common head. This method of presenting the material of interest to readers of MECHANICAL ENGINEERING has been adopted in this issue, and comments on the value of the news and of the changed method of featuring it are solicited.

It is appropriate at this time to call attention to the service provided by the American Engineering Council in its newsletter, sent monthly to member organizations, and to the portions of it that are published in MECHANICAL ENGINEERING. It cannot be too frequently recalled that the staff of the American Engineering Council is in a position to know what activities in Washington are of interest to engineers and what in general Washington is thinking with respect to them. The comments of the staff as represented by the news items published are thus, in most cases, interpretations of opinions and conditions formulated after much investigation and inquiry. For example, an item of a dozen lines may represent the conclusions of a member of the staff who has spent many hours and much leg work to get at information and points of view first hand. When this is realized and when the reader learns that MECHANICAL ENGINEERING has space for only those items most directly affecting mechanical engineers, the extent of the Council's work becomes more impressive.

But if the object of all this activity were merely to provide the few notes published in this and other engineering-society journals, engineers might well wonder if the results justified the time and money expended on them. What the average reader sees is a very small by-product of a greater and more important service. For in order to live up to its appellation of the "Engineers' Embassy" the Council must maintain a reliably informed staff whose services are constantly available to engineers, to the engineering societies that make up the Council, and to the governmental and legislative agencies in Washington who have come to look on the Council as a source of aid, advice, and information.

Viewed in this broader light the notes published by MECHANICAL ENGINEERING represent, then, only a few advance excerpts from the monthly newsletter of the Council which goes to all its member organizations, and thus they become merely by-products of a by-product. It would be most unfortunate if engineers individually were to assume that these fragmentary notes represented the major activities of the hard-working group in Washington. And lest such an impression should be gained by those unacquainted with the numerous phases of the Council's work, the Council has decided to include in its newsletter more information of its official actions and of the work of its committees. MECHANICAL ENGINEERING is glad to assist in publicizing these activities; and, as a case in point, attention is

directed to the note on page 311 of this issue describing briefly the work that has been done in connection with the patent situation.

Business and Management

IN THREE short lines appearing in the A.S.M.E. News section of the February issue it was reported that the annual assembly of the American Engineering Council noted to refer to its executive committee Mr. Flander's suggestion that "the Council bring about cooperation between its engineering-economics committees and social-science groups." Mr. Flanders recognized that the problems facing the nation today cannot be solved by one group alone because their solution requires not only the special skills of engineers but also the understanding and cooperation of those who have studied economic, social, and financial matters.

That we shall travel farther and faster with such cooperation than without it is obvious. With the period of recrimination drawing to a long wished-for end, a period in which each group has been blamed by the public for causing the depression and for failing in its leadership in recovery, and in which, at one time or another, members of each group have announced their peculiar claim to be considered the saviors of society, this spirit of cooperation is most encouraging. We can only hope for the best and aid in mutual understanding as greatly as possible.

Another instance of this same spirit manifested itself at a meeting of the New York Management Council, held in New York in February. At this meeting, for which about twenty-six engineering and management groups were cosponsors, Charles F. Roos, secretary of the Econometric Society, read a paper on the "Expected Contribution of Economic Theory and Measurement to Management." At the close of the meeting it was voted to refer to various economic and engineering groups the question, How can we get more economics in management?

It is not possible here to review the many arguments presented by Dr. Roos and those who discussed his paper. In calling attention to the meeting and the vote taken by those present the object in view is to awaken interest in the cooperative spirit which it manifests and to urge a thorough study of the advantages and limitations that are implicit in it.

Two points call for comment. One was made by John R. Shea, who called attention to some of the hazards of what may be termed preplanning on the basis of what is thought today may be profitable for tomorrow. The inevitable but sometimes unexpected consequences of change usually have pitfalls for the overenthusiastic planner.

The other point was made by Frederick C. Mills, who urged that in offering their services to management economists should not lose sight of their function and become merely clerks with special statistical skills, relinquishing their function as searchers for fundamental truths in economic relationships. This spirit can be cherished also by the engineer who, in his service to other groups, faces the possibility of ceasing to be an engineer and of becoming a public nuisance by entering fields in which he has neither authority nor even, in many cases, the ability of retaining his engineering realism of thought and method.

Thus, in order that success attend either of these ventures in cooperation, it is necessary that the true spirit of cooperation be kept in mind. If it is not, and if intelligent consideration is not given to the points of view of those having special knowledge in the many fields to be covered, cooperation is likely to break down, and the cooperators are likely to be discredited.

Elihu Thomson

PIONEER in the most fruitful era of applied science that the world has yet seen, Elihu Thomson, who died on March 13 in his eighty-fourth year, made contributions to the electrical age for which his countrymen long held him in respect as the "dean of electrical engineers." The list of his honors and of the official recognitions of his genius contains almost every significant acknowledgment that the engineers of this country and others have it in their power to bestow; but the one which bound him closest to mechanical engineers was honorary membership in The American Society of Mechanical Engineers.

In common with the most distinguished of the world's great inventors, Professor Thomson made contributions to an amazingly broad field of technology. Electric-resistance welding acclaims him as its originator. The electrical industry recognizes him as an early manufacturer, and his firm, the Thomson-Houston Electric Company, was combined with the Edison General Electric Company to form the General Electric Company. Engineering education is in his debt for his service, from 1921 to 1924, as acting president of the Massachusetts Institute of Technology. Nor were his inventions and investigations confined to electrical engineering, as Karl T. Compton showed in a tribute to some of his mechanical inventions that appeared in MECHANICAL ENGINEERING for April, 1933, on the occasion of Professor Thomson's eightieth birthday. Significant and timely for that tribute was the recognition of the research carried out on fused quartz, a monument to which exists in the 200-inch reflecting objective made for the world's largest astronomical telescope. Typical also as the avocation of many eminent engineers and scientists were Professor Thomson's astronomical studies and relaxations.

In the article by President Compton already referred to was a tribute to Professor Thomson which summarizes the man's unusual qualities. Said Mr. Compton:

> More than any man now living, or in fact more than any man in history, Professor Thomson has combined in a most remarkable way the constructive powers of the inventor, the thoroughness and soundness of the man of science, and the kindly balance of the ideal philosopher, teacher, and friend.

FIG. 1 CUTTING EDGE FINISH GROUND WITH A FINE ABRASIVE WHEEL (100×)

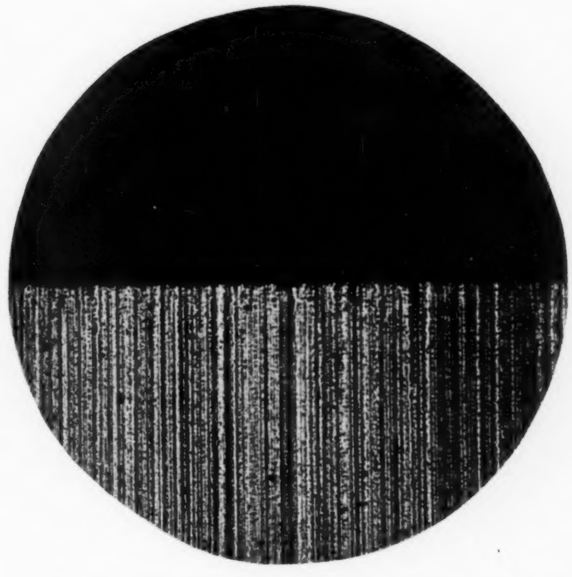

FIG. 2 CUTTING EDGE FINISH GROUND WITH A FINE-GRIT DIAMOND-WHEEL (100×)

GRINDING *of* CEMENTED-CARBIDE MILLING CUTTERS

By HANS ERNST AND MAX KRONENBERG

CINCINNATI MILLING MACHINE COMPANY, CINCINNATI, OHIO

GRINDING milling cutters tipped with cemented carbides introduces problems that are not encountered when grinding high-speed-steel cutters. Cemented carbides differ radically in nature from steel and, thus, require different grinding wheels and technique to obtain satisfactory results. They are much harder than steel, and thus cause much greater wheel wear. To produce a clean, sharp cutting edge with correct angles economically and without cracking the tip, special grinding wheels and devices and a rigid tool-grinding machine, in good condition, are required.

The average Brinell hardness for high-speed steel is approximately 650; while, in the case of tungsten carbide, it is as high as from 1500 to 1800. Owing to the difficulties encountered in measuring the hardness of these materials, the values given are useful only for a rough comparison. Machinability of a material decreases rapidly with increased Brinell hardness; common experience in the shop has shown that a cast iron of 200 Brinell hardness is much more difficult to machine than one of 150. Thus when grinding tungsten carbide, the grinding wheel breaks down more rapidly than with high-speed steel.

As a result of the relative brittleness of cemented carbides, producing a sharp cutting edge on these materials is also much more difficult than on steel. Grinding must, therefore, be done by removing a little material at each pass without trying to take the metal off too fast. Pressure between the tool and the grinding wheel must be light, and a constant motion in the direction of the feed must be maintained, to prevent localized heating of the cemented-carbide tip.

At present, practically all commercial cemented-carbide milling cutters use inserted blades; consequently, the following discussion will be limited to this type. The maximum permissible runout of a milling cutter having inserted blades tipped with the so-called "hard metal" is less than with high-speed-steel blades, because the former are much more sensitive to overloading. This overloading happens when one or several blades extend beyond the others and are the only ones that cut. Therefore, this condition must be avoided, especially with cemented-carbide blades.

ABRASIVE WHEELS

The relative hardness between work and wheel depends both on the hardness of the wheel and its speed. The higher the speed, the greater the apparent hardness. Providing a constant wheel speed is, therefore, desirable. When grinding on the periphery of a disk wheel, the diameter, and, hence, the surface speed, decreases rapidly due to heavy wear. With a cup wheel, however, the speed remains constant, regardless of the rate of wear. It is, therefore, to be preferred for grinding cemented carbide.

Use of cup wheels, however, involves a disadvantage due to the area of contact between wheel and work. This area is

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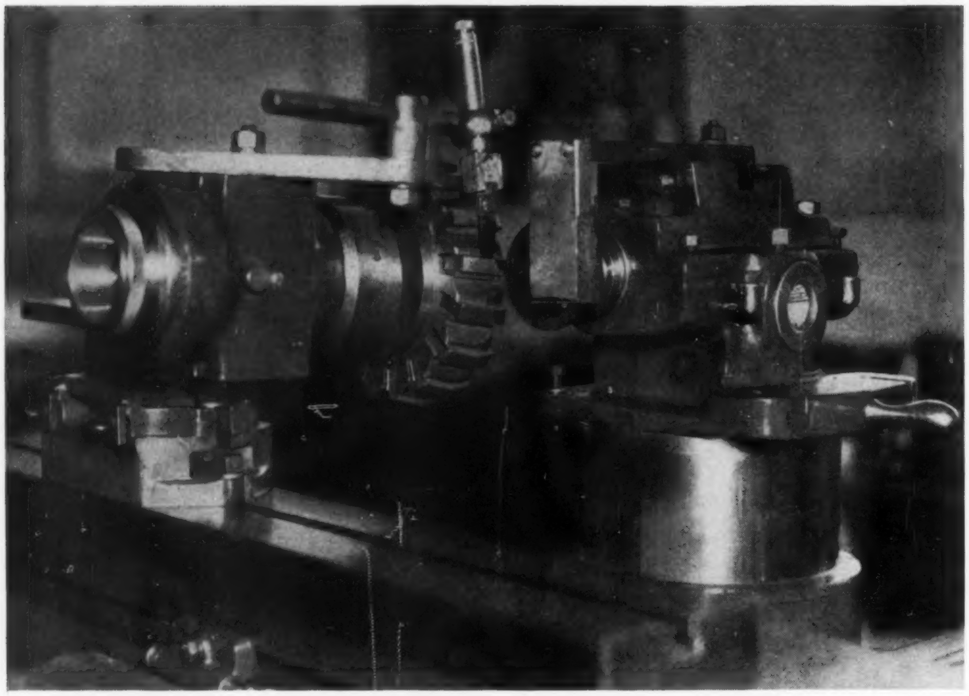


FIG. 3 SPECIAL FELT PAD MOUNTED ON HEADSTOCK OF CUTTER-GRINDING MACHINE TO SUPPLY CORRECT QUANTITY OF COOLANT

larger for cup than for disk wheels. For the latter, the contact between the wheel periphery and the tool to be ground is almost a line; while, for cup wheels, the contact between the side of the wheel and the tool is in a plane, which increases the danger of cracking or checking the tip. Furthermore, the size of the wheel determines the contact-plane area; the larger the wheel diameter, the greater the area of contact. This area, however, can be reduced by crowning the side of the cup wheel slightly, and its effect can be minimized by selecting the correct grade. Thus, for larger diameters, or where the wheel face is not crowned, the wheel should be softer and the grit coarser than in a disk wheel. Wheel diameters between $3^1/_2$ and 5 in. are recommended.

Present practice with the special abrasive wheels developed for grinding cemented carbides is to use a wheel speed of from 3500 to 5000 fpm. The trend, however, is toward the lower speed, in view of reducing heating and the better finish that is obtained.

The main factor determining the selection of a grinding wheel is the hardness of the material that is to be ground. This

TABLE 1

Carboloy	Firthite	Vascoloy Ramet	Widia	
X831	HF	D	M68	Most difficult
119A	HE	C	L31	
905	HA	S	H201	
883	HD	X	Normal	
44A	T41	B	XX	
77A	H	AAA	X	
77B	R	A	....	
906	HB	AA	....	
55A	HC	..	....	
...	T32	..	....	Least difficult

hardness and that of the wheel which should be used have a somewhat inverse ratio to one another. The harder the material, the softer and finer must be the grinding wheel, but, as yet, no definite relation based on scientific investigation is known. Softness of the wheel, in this connection, refers to its bond; the softer the bond the easier the grits can break out. When grinding cemented carbides, the grits break out more readily than with high-speed steel, because, in the latter case, with the softer material, the grits do not dull so quickly. Dull grits are, in effect, inefficient cutting tools; hence, the heat produced is greater, and the probability of loading is increased. As the grits become dulled, the space available for cooling decreases, thus further enhancing the likelihood of loading.

The difficulty of grinding various commercial grades of cemented carbide decreases from top to bottom in Table 1 which has been prepared by the Carborundum Company.

On the question of grinding dry or with a coolant, experts still do not agree. The tendency, however, seems to favor dry grinding, if the correct wheel speed and machine are being used. In any case, the use of only a small quantity of coolant must be avoided, as the danger of cracking the tip is then great, due to the different temperatures on various parts of the tip. A large quantity of coolant, however, prevents the operator from watching the grinding process and the sparks. Observation of the latter is particularly desirable when grinding hard metal. Another, and minor, objection to using coolant is that this practice generally necessitates wiping the individual cutter blades before setting-up for finishing with a diamond wheel.

Grinding-wheel manufacturers have developed special wheels for grinding hard metals. These wheels are green in color on account of the use of specially selected raw materials. They are made from a special grade of silicon carbide that is hard and sharp, while the bond gives an open porous structure, which is necessary to provide good cutting qualities.

For grinding milling cutters with hard-metal blades, the cup wheels listed in Table 2 are recommended by grinding-wheel

TABLE 2 CUP WHEELS RECOMMENDED FOR GRINDING MILLING CUTTERS WITH HARD-METAL BLADES

	Carborundum Company	Norton Company
Roughing	60S-WHG (range 60–80, R-T)	3760/1-J7 (dry grinding) 3760/1-I7 (wet grinding)
Finishing	120U-WIG (range 100–120, S-V)	37100-H7 (dry grinding) 37100-I7 (wet grinding)
Combination roughing and finishing	....	3780/1-I7 (dry grinding) 3780/1-J7 (wet grinding)

manufacturers. The numbers 60 and 120 in the symbols of the Carborundum Company represent the sizes of abrasive particles used; for example, a 60 grit will pass through a screen having 60 meshes to the linear inch. The letters S and U refer respectively to the grade or the tenacity with which the bond holds the grits. According to t e practice of this company, letters

toward the end of the alphabet indicate softer grades; thus, the U wheel is softer than the S. The three-letter groups represent details of manufacture, G standing for the green grit used for hard-metal grinding. In the Norton Company's symbols, the grit is indicated by the two or three numbers preceding the solidus; as for instance, the 60 in 3760 represents the particle size. Here, the letters toward the end of the alphabet indicate harder grades; thus, the J wheel is harder than the H.

DIAMOND WHEELS

Since the advent of cemented-carbide cutting tools, the life of a tool has repeatedly been shown to depend largely upon the keenness of the cutting edge and the smoothness of the face. Under the microscope, the cutting edge appears as an irregular saw-tooth line, even when ground with a fine-abrasive wheel. In service, the projecting portions produce irregularities in chip flow, with localized high stress concentration, thus causing an irregular breakdown of the cutting edge. With the fracture of each particle, the rate of breakdown increases, due to the heating and erosion produced by the metal escaping through the crevices. This condition is further aggravated by the resistance to chip flow caused by the roughness of the tool face.

To minimize this effect as much as possible, the cutting edge and face were generally lapped either by hand or by a cast-iron wheel charged with diamond dust or fine abrasive. This has led, in turn, to the development of a new-type finishing wheel, the diamond, by which cemented-carbide tools can be ground to a keen true edge with little heating. Fig. 1 shows the appearance under the microscope of a cutting edge that has been finish-ground with a fine-abrasive wheel, while Fig. 2 is a photomicrograph of a similar edge ground with a fine-grit diamond wheel. The improvement in the latter case is obvious. Diamond wheels are made from genuine diamonds that have been crushed by a special process, graded through a series of standardized screens, and mixed with a special bond. This mixture is then coated in various thicknesses, ranging from $^1/_{32}$ to $^1/_8$ in., on the sides and periphery of a backing wheel for side or peripheral grinding, respectively.

Using a diamond to true a diamond wheel is not recommended as the diamond dulls too rapidly. Small changes in the contour of the grinding face can be produced by a special abrasive dressing stick while running at a reduced speed. To correct any runout of a peripherally coated wheel, the flange nut should be slightly loosened, and the high side of the wheel tapped with the hand. To permit this adjustment, the arbor hole is made slightly oversize. To line, or straighten, the side of a cup wheel, it should be removed from the mount and rubbed by hand with a circular motion on a cast-iron plate sprinkled with abrasive.

Diamond wheels are made by the Carborundum Company in four standard grit sizes, 100, 180, 240, and 400, and three different diamond concentrations designated as A, B, and C; the first concentration has the smallest quantity in carats per unit volume. The Norton Company produces its diamond wheels in 100 grit for roughing, 220 for finishing, and 400 for extra-fine finishing. In addition, a general-purpose diamond wheel is produced with 150 grits for combination roughing and finishing.

Coolant must be used with a diamond wheel. This is usually oil, although kerosene and other fluids have been successfully used in certain cases. As shown in Fig. 3, a special felt pad may be provided to supply the correct quantity of coolant.

The cutting speed for diamond wheels should be approximately 50 per cent higher than that of abrasive wheels. This can be obtained by a two-step cone pulley. In the cutter-grinding machine shown in Fig. 3, the pulley provides speeds of

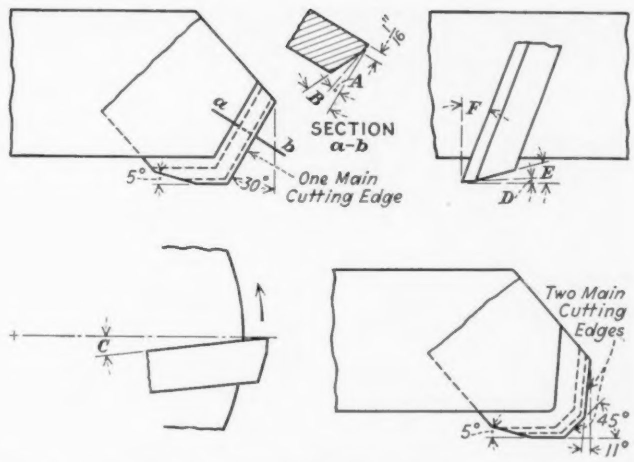


FIG. 4 VARIOUS ANGLES TO WHICH CEMENTED-CARBIDE MILLING-CUTTERS ARE GROUND

3850 rpm for the roughing process with abrasive wheels and 5735 rpm for finishing with diamond wheels.

Diamond wheels can be cleaned by a pumice stone. This should be moved continuously across the face of the wheel.

CUTTING ANGLES REQUIRE STANDARDIZATION

No standard practice regarding cutting angles has been agreed upon by makers of milling cutters either in America or abroad. The angles given in Table 3 are those recommended by the Cincinnati Milling Machine Company for use under average conditions. For exceptional cases, better results may be obtained by varying certain of these angles within narrow limits. Angles *C* and *F*, however, are fixed by the direction in which the slot has been milled in the cutter body.

TABLE 3 RECOMMENDED ANGLES FOR GRINDING MILLING CUTTERS

Angle (see Fig. 4)	*A*	*B*	*C*	*D*	*E*	*F*
Cast iron	4	8	5	3	6	3
Aluminum	8	12	30	4	8	30

The clearance angles *A* and *D* should be as small as possible to avoid the tendency to chatter which is often the cause of cutting-edge breakdown. All these angles, however, should be standardized wherever possible; otherwise, each tool-grinding machine operator will exercise his own judgment with disastrous results. In any event, a special cutter-clearance protractor should be provided, and the angles should be measured carefully and recorded for reference. Results will then indicate desirable practice.

Considerable variation in practice exists in regard to the form of the cutting edge. That shown in the upper left corner of Fig. 4 has been used extensively for cemented-carbide milling cutters and possesses the advantage of having only one main cutting edge inclined at an angle of 30 deg to the axis of the cutter. This obviously reduces the time required for grinding and avoids the crowding of the chip which exists when two main cutting edges are used as in the form that is shown in the lower right corner. The latter form, however, is still widely used, crowding of the chip being somewhat reduced by grinding the peripheral cutting edge at an angle of 11 deg with the axis. This is possible, of course, only when the periphery of the cutter is not required to produce a wall perpendicular to its face.

Two clearance angles are recommended for both the major and the minor cutting edge. The reasons for the secondary clearance angle are as follows:

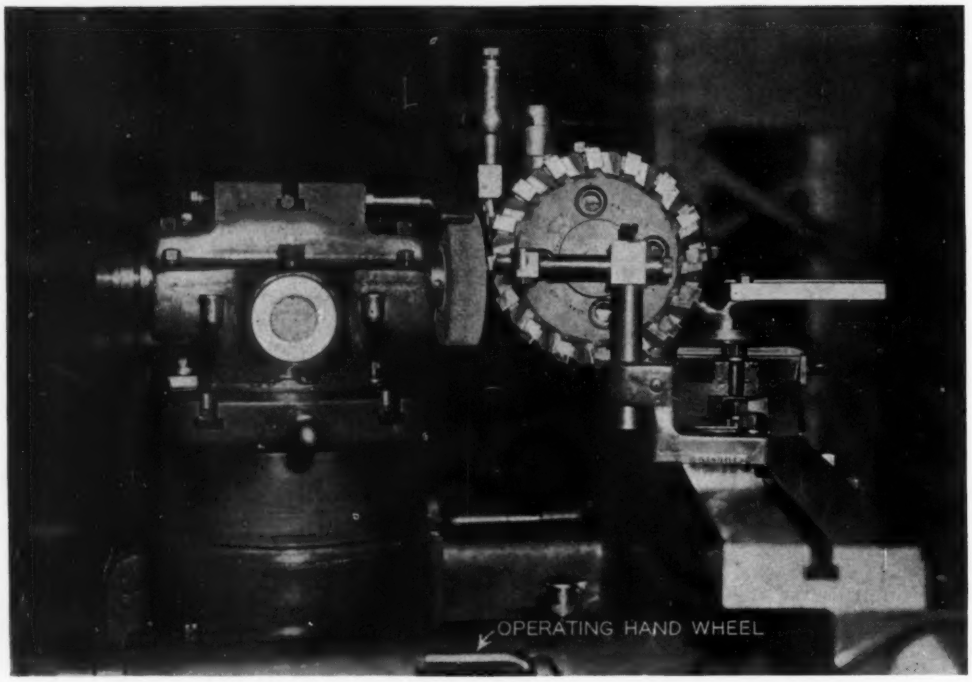


FIG. 5 GRINDING THE PERIPHERY OF MILLING-CUTTER TEETH

(The truing device used as a gage to insure uniform grinding of all teeth is shown in position.)

(1) To permit use of small primary clearance angles, yet avoid interference between the back of the tool and the work.

(2) To obtain a larger included angle at the cutting edge, thus providing better heat conductivity and support of the cutting edge.

(3) To prevent contact of the abrasive finishing or the diamond wheel with the steel blade, which would cause wheel loading and, as a result, produce a bad finish on the tip.

Due to repeated grinding, the width of the land will increase, thus causing interference with the work. When this occurs, the secondary clearance angle must be reground.

Accurate grinding is essential for the successful use of cemented-carbide milling cutters. Practice has indicated that the difference between the highest and lowest teeth for both face and corner, must not exceed 0.0005 in. The lowest tooth should be marked and ground first. If one blade extends considerably beyond the others when they are assembled preparatory to grinding, time will be saved and wheel life prolonged by either readjusting the blade or removing and grinding it independently.

When using an abrasive wheel, the required accuracy is obtained either with an indicator reading to 0.0001 in. or by a special diamond truing device, as shown in Fig. 5. The sound produced when using a diamond wheel, which can be heard by a skilled operator, and the disappearance of the sparks give the best indication that sufficiently true surfaces have been obtained. The finishing diamond wheel should remove only the surface roughness left by the abrasive wheel.

Milling cutters with hard-metal tips should generally be of the inserted-blade type, so that a damaged blade can be removed and repaired without destroying the others. The body should be specially designed for use with blades of this type. They should be backed-up rigidly, as near as possible to the cutting edge, and the slots placed at the proper angle. Cemented-carbide milling cutters for machining aluminum and other light metals should have a small number of teeth. In many cases, cutters with only four teeth have been used and given satisfactory results.

Breakage of cemented-carbide tips is sometimes caused by wrong methods of fastening them to the blades. A satisfac-

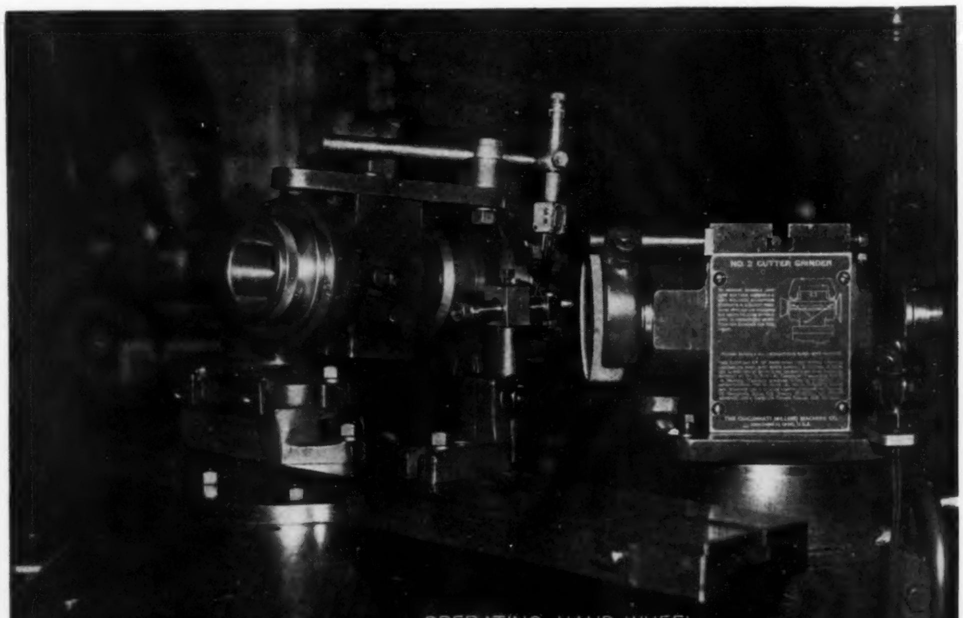


FIG. 6 GRINDING THE CORNER OF MILLING-CUTTER TEETH

(The freely moving table with an antifriction support can be controlled from either end of the cutter-grinding machine and aids the operator in determining when the grinding operation is complete.)

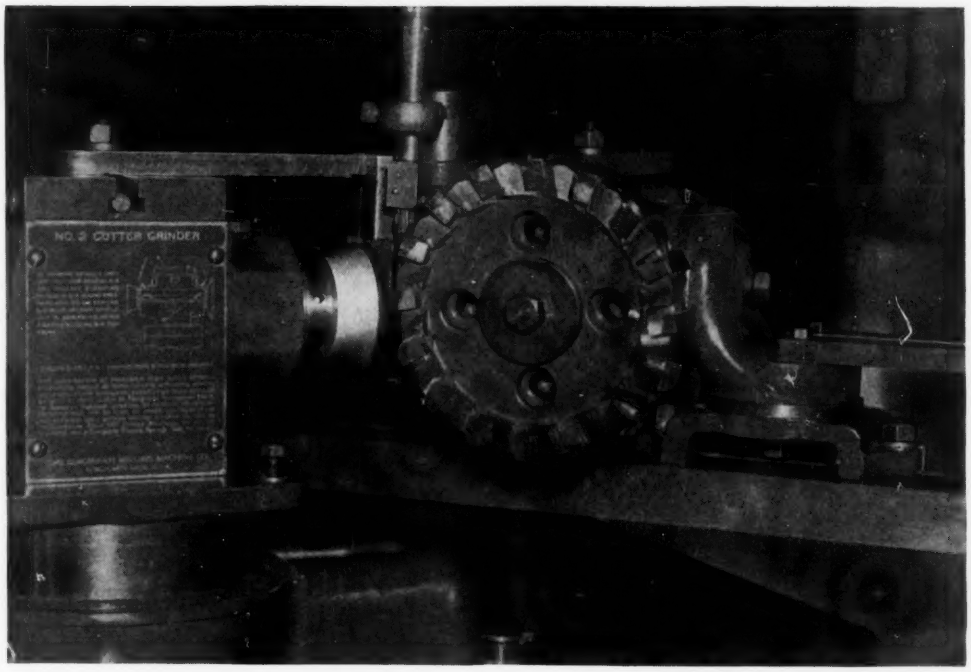


FIG. 8 AFTER THE TOOTH CORNER HAS BEEN GROUND, LAPPING WITH DIAMOND WHEEL COMPLETES OPERATION

tory practice is to braze the tips on the blades by perforated electrolytic-copper foil, using a temperature of approximately 2100 F and a muffle furnace to avoid contact of the flame with the tool, as would be the case in other furnaces. The open flame would cause oxidation of the surfaces to be brazed together, thus preventing a satisfactory joint. The holes in the foil permit a free flow of copper in all directions, while, with unperforated copper foil, the brazing material may have a tendency to lift the tip, due to expansion.

Grinding should always be done against the cutting edge, which means that the wheel should rotate toward it. To provide a senistive, yet positive, control of the grinding process, feeding the work past the wheel should be done by hand rather than by power, thus permitting the operator to adapt the feed to the depth of cut at all times. In this connection, a freely moving table, which is provided by an antifriction support, as shown in Fig. 6, has been found of great value. In all cases, the feed should be light, and not more than 0.0002 in. should be removed per pass.

In each shop, a man should be selected and trained in grinding milling cutters with cemented-carbide blades. A skilled operator is able to estimate the stock that he removes by the magnitude of the sparks and the sound of the grinding process, which is clearer when grinding hard metal than with high-speed steel. He should also practice using a diamond wheel, which at first gives a hard sound that disappears when the correct surface has been reached. After a short time of practice on a cutter-grinding machine with an antifriction table support, the operator can feel the work resistance from the handwheel and also its disappearance when the operation is completed.

The tool must be kept constantly in motion to prevent excessive localized heating and consequent damage of the tip. Grinding time required in each particular case depends upon the number of cutting edges, the wear of the blades, the number of teeth, the operating convenience of the machine, the accuracy that should be obtained, and the training of the operator.

No standard practice regarding the number of stages of grinding employed has yet been adopted. Where wear is heavy, grinding with a roughing and a finishing abrasive wheel, followed by lapping with a 100-grit and a 400-grit diamond wheel, may be necessary. For average wear, practice has shown that the 100-grit diamond wheel with a medium concentration produces a surface that is at least as good as one produced with a 120-grit

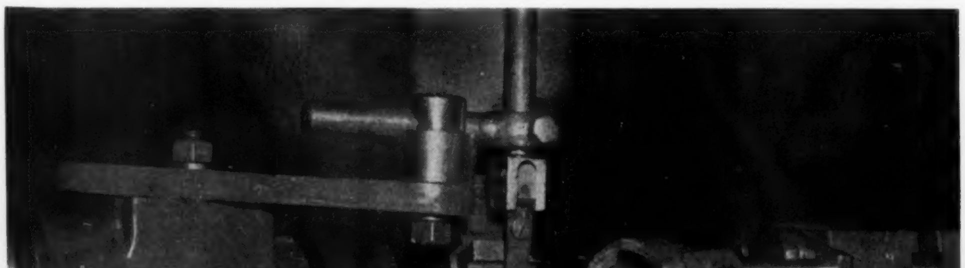


FIG. 7 GRINDING THE FACE OF MILLING-CUTTER TEETH

abrasive wheel. Hence, the finish-grinding operation with the abrasive wheel can often be omitted. The trend in grinding cemented-carbide face-milling cutters now appears to be more and more in the direction of using diamond wheels both for roughing and finishing, due to the reduction in heat developed.

The use of only one main cutting edge, as shown at the upper left corner of Fig. 4, permits a considerable saving in grinding time. The wear on the face is often small so that regrinding is not always necessary.

To maintain a satisfactory finish on the surface being milled, cutter wear should not be allowed to proceed too far. Tests on the milling of cast iron have shown that the quality of finish deteriorates rapidly after abrasion of the cutting edge has extended back along the flank between 0.008 and 0.010 in. Further breakdown of the cutting edge also increases rapidly after abrasion passes this point. In practice, cutters are often permitted to wear beyond this point, but that procedure is not recommended.

PRACTICAL APPLICATION OF THE PROCESS

To illustrate how the foregoing recommendations for grinding cemented-carbide face-milling cutters can be carried out in practice, the following example is given of a commercial cutter-grinding machine. Figs. 5–9 show the No. 2 cutter-grinding machine built by the Cincinnati Milling Machine Company grinding a cutter with two main cutting edges, on periphery and corner, and one minor edge on the face, similar to that illustrated in the lower right corner of Fig. 4. The machine is adapted to the use of both green-grain abrasive and diamond wheels.

Fig. 5 shows the periphery of the teeth being ground. Due to the rapid wear of the grinding wheel on cemented-carbide blades and the accuracy desired, special truing devices are necessary. The device should be adjusted to the first tooth to be ground, which usually should be the lowest one. Then, it is used as a gage for all other teeth and should, therefore, not be adjusted until all teeth are ground. Thus, an indicator is unnecessary.

The setup for grinding the corner of the teeth with the machine table swiveled in accordance with the angle of the corner is illustrated in Fig. 6. The truing device is again used as a gage for all teeth after having been adjusted to the first tooth. The diamond can be adjusted in any desired plane and can be set by a micrometer screw. This is a considerable advantage in obtaining the required accuracy.

As has been mentioned previously, the antifriction table slide is of special importance in providing the sensitiveness of hand movement needed to obtain the accuracy required in grinding cemented-carbide cutters. This table is also of considerable value in preventing the operator from tiring, which would otherwise occur in a short time. If the operator becomes tired, he loses the feeling for the quantity of material removed, the accuracy decreases, and the grinding time increases. The antifriction table slide, with control handwheels on both sides of the machine, is shown in Figs. 5 and 6. Thus, the operator can stand at either end of the table.

Grinding the face of the teeth by swiveling the headstock in the horizontal plane is illustrated in Fig. 7, which also clearly shows the tooth rest abutting against the back of the teeth. Fig. 8 shows the setup when lapping the corner with a diamond wheel. Here, the table is swiveled to the same angle as in Fig. 6. A truing device is, of course, not necessary when using the diamond wheel. Fig. 9 illustrates the diamond wheel lapping the peripheral cutting-edge.

Smooth rotation of both diamond and grinding wheels is essential in obtaining the accuracy necessary for a cemented-carbide-tipped cutter. As can be seen from Figs. 5 to 9, the motor of this machine is not mounted on the main spindle and is also not connected to it by gears but drives it through a belt connection, the motor itself being located near the bottom of the machine.

For accurate work, the face of the cutter body that abuts against the milling-machine spindle must be truly flat. If it is not, the cutter body will be distorted when bolted to the spindle nose, and, thus, the radial cutting edge will no longer lie in a true plane perpendicular to the cutter axis.

In conclusion, to obtain optimum results with cemented-carbide milling cutters, the cutter body must be rigid and accurately made, and the grinding of the blades must be carried out in accordance with the foregoing recommendations so as to produce keen, true, and uniform cutting edges.

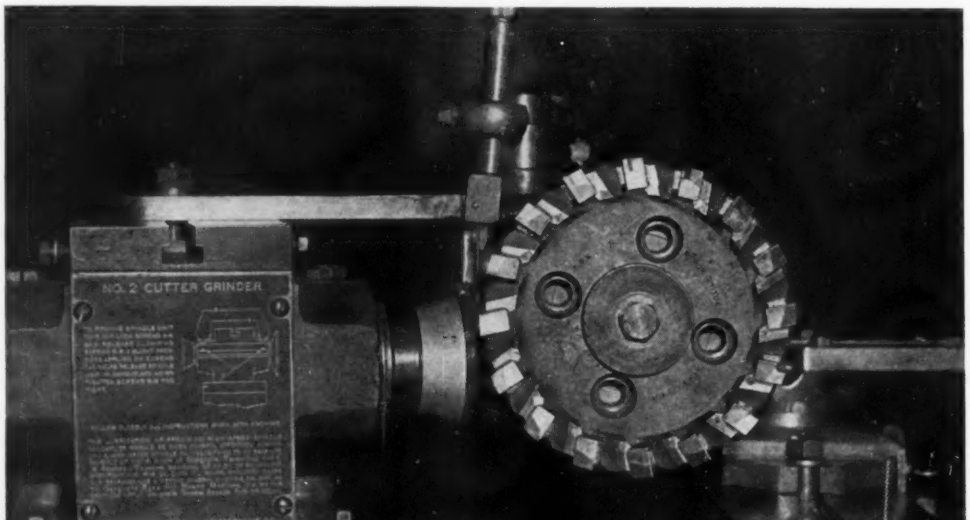


FIG. 9 LAPPING PERIPHERAL CUTTING EDGE WITH DIAMOND WHEEL

The AUTOMOBILE INDUSTRY *and* YOUNG ENGINEERS

By C. J. FREUND

COLLEGE OF ENGINEERING, UNIVERSITY OF DETROIT

WITHIN a generation, the automobile industry of the United States has grown from practically nothing to the most spectacular, if not the most important, manufacturing industry. In 1929, American manufacturers built more than 5,500,000 cars,[1] about thirty times as many as in 1910. This growth of 2900 per cent compares with an increase of 20 per cent in bituminous coal production,[2] 25 per cent in newsprint production,[3] 100 per cent in portland-cement production,[4] and 50 per cent in pig-iron production[5] in those same 19 years.

The automobile industry is the outstanding demonstration of the American genius for incessant, restless, technical improvement and for building and organizing huge enterprises. Americans are just as proud of the automobile industry as a Greek is proud of the Acropolis, or an Englishman is proud of a green, English countryside. Building automobiles is romantic, just as building railroads was romantic fifty years ago and sailing clippers a hundred years ago. Naturally enough, thousands of young engineers and engineering students hope to become useful, or even famous, in the industry. They want to know if automobile engineering is distinctive or unique in any way. Engineering, of course, is the application of physical science, in the automobile industry as it is in any other, but what skills will they need? What manner of men must they be? How should they prepare themselves?

These questions were submitted to the following: B. H. Anibal, vice-president in charge of engineering, Pontiac Motor Company; J. J. Caton, educational director, Chrysler Institute of Engineering; F. O. Clements, technical director, research laboratories, General Motors Corporation; J. M. Crawford, chief engineer, Chevrolet Motor Company; F. F. Kishline, chief engineer, Graham-Paige Motors, Inc.; C. R. Paton, chief engineer, Packard Motor Car Company; E. W. Seaholm, chief engineer, Cadillac Motor Car Company; and L. S. Sheldrick, engineer, Ford Motor Company.

After thinking and talking about these questions for an hour or two in his own office, each formulated his answers. To make interpretation easier, their answers will be compared with answers to identical questions about the power and communication utilities. Young engineers know almost nothing about the automobile industry but they do know considerable about the utilities. Utility personnel officers visit the colleges regularly and tell the story of their industry to faculties and students. More engineering graduates have gone into the utilities than into any other industry and have been most successfully trained and assimilated. The following utility officials have kindly answered the questions: E. C. Balch, chief engineer, Michigan Bell Telephone Company; Dr. C. F. Hirshfeld, chief of research, Detroit Edison Company; J. W. Parker, vice-president and chief engineer, Detroit Edison Company; and L. J. Schrenk, general superintendent, Detroit Public Lighting Commission.

METHOD USED TO SECURE THE INFORMATION

The first question put to both the automobile and the utility engineers was: "What is the relative weight or value of calculation and analysis, experiment, performance records, and precedent in the design and development phases of your industry; not in any given project or job, but on the average, over a year, for instance?" Plant engineering, maintenance engineering, works management, and the like were specifically excluded.

Both groups of engineers answered, on the average, as indicated in Table 1.

TABLE 1 ANSWERS TO A QUESTIONNAIRE REGARDING RELATIVE WEIGHT OF DIFFERENT SUBJECTS

	Automobile engineers, per cent	Utility engineers, per cent
Results of day-by-day experiment, test, and observation	33	20
Formal, recorded accounts of the performance of machinery or equipment in operation	23	20
Mathematical or engineering calculations, based upon fundamental engineering principles and formulas	22	34
Accepted standards, procedures, and precedents of the industry	22	26
Total	100	100

Of course, these are mere estimates as measuring such values is extremely difficult, if not impossible. However, the first and third items support the prevailing opinion that the automobile engineer performs experiments and checks the results of his experiments by theoretical calculation if he has to, while other engineers perform calculations and check the results of their calculations by experiments if they have to. An engineer will ordinarily complete the design for the main bearings of a 10,000-kw steam turbine right on the drawing board, or at least within his office or the engineering department; the engineer who is designing main bearings for a new eight-cylinder internal-combustion engine may very soon start a test in the laboratory to obtain information that he needs badly but has not in his possession.

"Trial and error still play a large part in the development of the automobile, perhaps more than they should," a prominent automobile official admitted not long ago. According to W. S. Knudsen, executive vice-president, General Motors Corporation: "The automobile industry does not go far in theoreti-

[1] "America's Capacity to Produce," by E. G. Nourse and associates, Brookings Institution, Washington, D. C., 1934, p. 229.

[2] *Ibid.*, p. 53.

[3] *Ibid.*, p. 584.

[4] *Ibid.*, p. 126.

[5] *Ibid.*, p. 252.

Contributed by the Committee on Relations With Colleges for presentation at the Semi-Annual Meeting, Detroit, Michigan, May 17–21, 1937, of The American Society of Mechanical Engineers.

cal study before parallel experiments are begun on actual models or specimens. If the experiments are satisfactory, the design is accepted, and this implies no disregard of theoretical science because the industry is young and not very much scientific information is available as yet."

Prof. A. Klemin wrote of Chrysler engineering practice:[6] "No matter how carefully a part may be designed, no matter how well-selected the materials employed, the ultimate safeguard lies only in indefinitely repeated tests under conditions representing the severest requirements of actual use."

The character of the industry undoubtedly has much to do with it. A test car can be justified if 500,000 of the model are to be manufactured and sold; but only a single set of turbines was built for the *Queen Mary*, and that one set *had* to be right.

QUALIFICATIONS REQUIRED OF AUTOMOBILE ENGINEERS

The next question put to the engineers was: "What is the relative value of the qualifications listed in the engineers whom you employ?" The average answers are given in Table 2.

TABLE 2 RELATIVE VALUE OF VARIOUS QUALIFICATIONS IN ENGINEERS

	Automobile engineers, per cent	Utility engineers per cent,
Practical common sense; judgment	27	27
Engineering-college degree	19	17
Broad experience in drafting, estimating, and calculating	17	13
Manufacturing, shop, or operating experience	14	14
Familiarity with product or equipment in use; experience in the field	13	17
Advanced scientific or technical training; graduate studies	10	12
Total	100	100

Such close agreement could hardly be expected. An inquiring and skeptical senior student protested, "But all that tells us only what the chief engineers think they want. Maybe what they really need is something altogether different. Perhaps they have never made an analysis to find out just what qualifications their engineers ought to have."

This student may be right. Even knowing what qualifications the chief engineers think they want in an applicant will at least help him to get a job, since the chief engineers are the men who do the hiring. After the applicant has obtained employment, he can figure out as he goes along, exactly what the actual requirements of his job are.

Now, what kind of men are the automobile engineers as a matter of fact, and how far apart from the kind of men the chief engineers think they ought to be? What training have they had? What have been their experiences? The chief automobile and utility engineers were kind enough to circulate a schedule among the more important or representative men in their respective organizations, who returned the data presented in Table 3.

The first of these items suggests that the automobile industry may be the last stronghold of the self-made engineer. The typical automobile engineer is hardheaded and practical. He pooh-poohs tradition and precedent because little of either is to be found in his business. He is independent and irreverent. Other engineers respect the established engineering principles and laws, and they are proud of the remarkable machines

[6] "How Research Makes Possible the Modern Motor Car," by A. Klemin, *Scientific American*, vol. 151, August, 1934, p. 63.

TABLE 3 DATA ON GROUPS OF AUTOMOBILE AND UTILITY ENGINEERS

	Automobile engineers	Utility engineers
Engineers in group	199	46
College graduate engineers in each group, per cent	58[a]	85
Average time in design, development, or research in each group, years	13.1	9.13
Average time in practical manufacturing or operating employment in each group, years	3.56	11

[a] If the research division of the General Motors Corporation is excluded, this figure would be 53 per cent. The assumption is that those who spent 4 or more years in college were graduated.

and structures that they can perfect in compliance with those principles and laws. The automobile engineer is just as proud when he works out a successful machine or device which seems to contradict the known laws and principles of engineering. He may not know how to reconcile the two and seldom makes any effort to learn. Should a scientist endeavor to effect a similar reconciliation and fail in his attempt, the engineer is likely to scoff at him.

The automobile engineer tends to become primarily an automobile man and to acquire an automobile consciousness and viewpoint, and, if he gradually forgets his distinctive engineering interests and associations, nobody in the industry will care much. Some automobile engineers take the dignities and ceremonials of their profession seriously, but probably many more secretly despise or openly ridicule registration by state boards, membership in learned societies, honorary degrees, medals, and all such.

To the outsider, the automobile engineer appears to prosper, more than others, in proportion as he contributes materially and directly to the well-being of his employer. He is expected to tend exclusively to his business, and, incidentally, in one or the other corporation, he will soon learn that miscellaneous engineering-society and civic activity are not considered part of his business. In one or the other corporation he will soon learn—if he wants to keep his job—that any local or national publicity accrues to the name of the corporation, or its chief officers, and to nobody else. Thus, the young engineer may find it worth-while to hide his professional light under a bushel, because the automobile industry expects much but pays well.

GETTING INTO THE INDUSTRY

Engineering-college seniors know all about the two-year apprenticeship or "test" courses of the General Electric Company, the Westinghouse Electric & Mfg. Co., and many others. They ask, "Can I get that kind of thing in the automobile business?"

Only the Chrysler Corporation has such a plan. In the Chrysler Institute of Engineering, established in 1933, college graduates pursue a well-organized two-year program of work in the engineering department and attend afternoon or evening classes in advanced engineering subjects, taught mostly by the Corporation's own engineers. The Chrysler engineering forces are normally recruited only through the Institute. Although no other formal program of the sort exists in the Detroit area, all chief engineers are much concerned about getting the best possible talent into their organizations. Each has a method of his own.

One well-known engineer explained: "We inquire of the colleges about promising young freshmen and sophomores, and get reports of the work they do from year to year. Sometimes, we employ a selected group of these students during the summer vacation following the junior year and watch them

closely. We may hire a few of the best of them after they graduate."

Another said: "We definitely are not interested in getting boys directly from college. They must come in through the shop. I look up college graduates employed out in the plant and watch them at work. If they are handy and alert, I get them transferred to the experimental laboratory, and, if they do well there, I promote them to the engineering department."

A third chief engineer likewise searches in the plant for his recruits but brings them directly into the engineering organization, omitting the laboratory. A fourth has complete confidence in the college personnel or placement officers, hires as many of their recommended graduates as he needs, and after that they have exactly the same status as any other employee in the department.

A fifth chief said: "The placement fellows from the colleges always send us more applicants than we can ever put on. We pick out the best of them if we have to hire men. We try them out in the test laboratory and take them up here if they make out. Then, we send them into the shops on every possible errand. Sometimes, they work out there on some problem for weeks at a time. It's a first rate kind of training."

ACTUAL OPPORTUNITIES FOR ADVANCEMENT

"What chance is there of getting a job here and now, at any given time? What are the day-by-day opportunities?" That is another thing young engineers and students wish to know about the automobile business. Automotive engineering is a large and an expanding field but that does not necessarily mean that long queues of young hopefuls can be hired in a single morning, like toolmakers when work begins on the new models. Indeed, it means nothing of the kind.

In the first place, automobile engineers seem to be a comparatively stable group with little over-all turnover. They migrate to some degree from one corporation to another, but the experienced engineer who leaves one plant will be found in another the next morning if business is good, and after a few months or a year if it is not. Officials demand experience. If the applicant is experienced, they care little whether or not he has a college degree; if he has no experience, a brief case full of diplomas will not do as a substitute. The industry has grown rapidly and still is unstable. Engineering officials have been so harassed by each day's problems that they have had no time to plan or even think about the systematic development of succeeding generations of engineers.

Besides, the competition is terrific. A dozen young engineers will scramble for a single little opening, and thousands would if they knew about it.

People will tell you that automobile officials are prejudiced against college graduates. Chief engineers, indeed, do not pamper college graduates and will not start them halfway up the ladder just because they have a degree. The chiefs have work to do and look for men who can do it. If those men are college graduates, well and good; if they are self-made, well and good, too. Some of the chief engineers have not even bothered to find out which of their men are college trained and which are not. They expect the college graduates to compete with others on the basis of their ability to get out good work and on that basis only. If that constitutes prejudice, then a prejudice against the college graduate exists in the automobile industry and plenty of it.

MOST VALUABLE COLLEGE STUDIES IN ACTUAL WORK

The automobile chief engineers asked the 199 leading men in their departments: "Which college studies do you now find useful in your work, either directly or indirectly?" Some few did not answer the question, but the great majority did, and the results are presented in Table 4. No other subjects were named more than a few times.

TABLE 4 COLLEGE STUDIES, THAT 199 AUTOMOBILE ENGINEERS CONSIDER USEFUL IN THEIR WORK

Subject	Times mentioned
Mathematics	98
Physics	58
Mechanics	54
Engineering design	31
English	22
Drawing	20
Strength of materials	19
Chemistry	18
Electrical-engineering courses	13
Mechanical-engineering courses	12
Shop practice	12
Thermodynamics	11

Old-fashioned mathematics, physics, and mechanics are overwhelmingly in the lead, suggesting that the current clamor for emphasis on the fundamentals is no mistake. In view of the prevailing methods in automobile engineering, the college boy who is ambitious to get into the industry must surely become proficient in the use of instruments and in laboratory technique.

Nor must he forget that he must work, and live, with his fellow citizens. C. B. Veal, research manager of the Society of Automotive Engineers, put it simply and directly when he wrote: "The engineer is sunk who relies on the laws of nature and neglects the more involved, and much less understood, laws of human nature."[7] The student must learn about the past and the present of the world of men and affairs. In other words, his curriculum must have cultural values, but the teachers of any first-grade American college of engineering will tell him that over and over.

PROSPECTS FOR THE FUTURE

Herman Weckler, vice-president, DeSoto Motor Corporation, maintains: "It is impossible to foretell the future growth of the industry, or whether there will be any growth at all. I do know that, in 1914, surveys were made to determine how nearly saturated the automobile market had become. But, in the light of later developments, the market had hardly opened at that time. Similarly, there is no telling now what the future has in store. Theoretically, at least, the market can expand until there are several cars in most families that now have only one."

William S. Knudsen, executive vice-president of the General Motors Corporation, thinks: "The industry is now pretty well stabilized as far as volume of business is concerned. I do not myself look for any vast growth in the future. What growth the industry will enjoy will probably result only from appeal made to the public by a greatly improved product."

The automobile business is not on the defensive now and probably will not be for years to come. In time, some strange, new enterprise, colorful and fascinating, will capture the American imagination and crowd the automobile industry from the stage. After that, building automobiles will be just something that has to be done, like making cotton cloth, or furniture, or wheat flour. Then, junior engineers and graduates will easily be able to find jobs in automobile manufacture, but they will refuse to accept them. They will all be striving frantically to get into that newer, more colorful, more fascinating industry.

[7] "Application of Imagination," by C. B. Veal, *S.A.E. Journal*, vol. 35, December, 1934, p. 443.

MARKET RESEARCH

Aids Industrial Sales Promotion

By E. J. KLOCK

MARKET-RESEARCH DIVISION, GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

MARKET RESEARCH is collecting and interpreting facts on markets and marketing. The late depression must have forcefully shown many sales-promotion executives the need for greater knowledge of these subjects. While market research cannot solve the sales manager's every problem, it can assist in answering some perplexing questions.

Exact size of a market probably is not important, but whether that market amounts to roughly $1,000,000 or $10,000,000 is. The sales-promotion manager must know the approximate size to budget a reasonable amount for promotion and to measure his performance in terms of business available. With a new product, the question arises whether an adequate market exists or can be developed profitably. Occasionally, a market study shows little need for the product and that nothing should be done.

A control device for automatically changing letters on theater marquee signs was offered to us for manufacture and sale. In investigating this market, leading theater-chain executives were interviewed, and letters on small, medium, and large theater signs were counted as a basis for estimating the cost of a typical installation. Opinions and facts thus obtained indicated clearly that the market for this device would be inadequate, and it was not manufactured.

Industrial sales of one product seemed low. A market study indicated a surprisingly large market and its location. An intensive sales campaign was conducted, the opportunities in this market were stressed to the sales force, and industrial sales of this product increased substantially.

The sales manager needs to know who his best prospects are and where they are located to direct his efforts to the proper places. For many lines, this is no problem; but, for some products, the principal users are not immediately apparent. A market-research group aids the sales manager by determining which industries are large users of these products and the names and addresses of the principal users in these industries.

Sound practice dictates listing all possible product-applications. However, the sales manager needs to know those particular applications that represent the largest volume of present business and offer the greatest promise; these are the ones to stress. Knowledge of the most important applications can be obtained by a properly conducted market-research study among the product's users. Of many possible applications for atomic hydrogen welding, the one offering the greatest increased-sales opportunities was determined by a market study.

The greater part of General Electric's apparatus sales is handled direct. However, an appreciable part of the total sales in some lines is handled through distributors, while some competitors obtain the greater part of their business direct. Study of each sales channel's relative advantages and disadvantages in coverage, sales, and costs may indicate profitable changes.

Occasionally, with a new product, none of the present sales channels is suitable. A market study for a proposed product showed that neither the apparatus-sales organization, the appliance or merchandise organization, nor the dealers and distributors of either, were set up to sell the product. In their established contacts, they did not deal with individuals who would purchase a product of this kind, and could not afford to spend the time necessary to establish these contacts for this one product.

Seldom can the sales manager learn exactly what his customers desire and here, again, is where he makes use of market research to help him solve a problem. Which of a product's many features are important to customers? Which, if any, do they dislike? What features that are not incorporated in the product would they like? Knowing the facts that answer these questions, the sales manager can decide what features to stress. Also, he may be able to improve the product; even though incorporating all the features that customers desire may be inexpedient, because of engineering or manufacturing difficulties or necessary increases in cost.

For a certain electrical-equipment product, the natural assumption was that accuracy was important and should be particularly stressed. A market study was made to find out what features users considered most essential. This study showed that the largest users built the product into their equipment and considered appearance of major importance and a high degree of accuracy a relatively minor point.

In a study of the refrigerated truck-body market, users stated their preferences as to type of refrigeration, styling, and similar features. The new G-E refrigerated truck-bodies incorporate many of the features that users desire, and these, of course, are stressed in advertising.

What the sales manager, the advertising manager, or the engineer consider a strong appeal may have little influence on customers. What the sales manager needs to know is what the customers, as a group, think. Through market research, prospects' reactions to various suggested appeals have been obtained as a basis for selecting in advance those likely to have the greatest influence. Once, a letter was sent to numerous motor buyers asking them to rate five illustrated sales appeals in order of interest. These were rough sketches of proposed advertisements showing the headline or appeal and the illustration. Appeals that these purchasers considered most effective were used.

"New" is a magic word to many buyers, anxious to take advantage of new developments. However, a study showed that buyers in a certain industry were not interested in a new type of product, fearing unsatisfactory service. This indicated that the industry should be approached on the basis of the product's tested dependability and high quality, not its newness.

Does the electrical contractor, the machinery manufacturer, or the user specify the make or brand of electrical equipment? Does this practice vary significantly between large and small users? Studies have been conducted to answer these and other related questions, so that sales messages will be directed to the proper person. With individual companies, the salesman

(*Continued on page 262*)

Contributed by the Management Division and presented at a meeting of the Metropolitan Section of The American Society of Mechanical Engineers, Oct. 14, 1936, New York, N. Y.

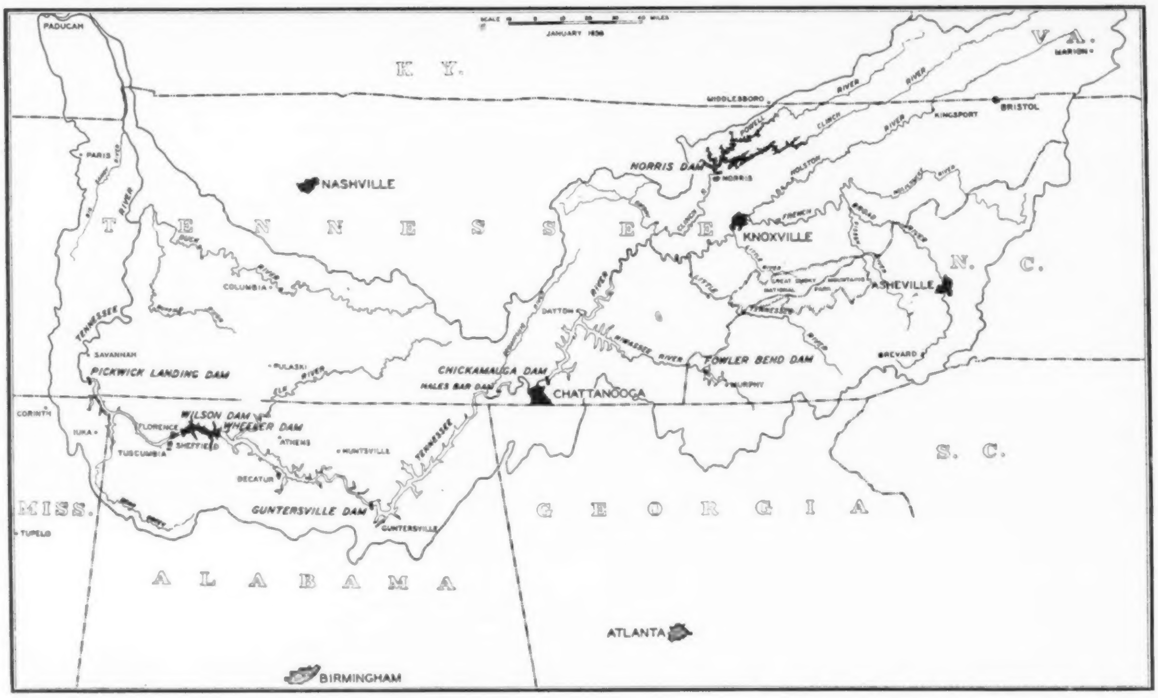


FIG. 1 TENNESSEE RIVER BASIN SHOWING LOCATION OF WHEELER DAM

270-Ton Double-Trolley GANTRY CRANE *at* WHEELER DAM

By M. R. BOWERMAN

THE ALLIANCE MACHINE CO., ALLIANCE, OHIO

WHEELER DAM is located on the Tennessee River at the head of Wilson Lake, 15.5 miles above Muscle Shoals, Ala. (See Fig. 1.) Construction work was started in November, 1933. The dam is primarily for navigation, but surplus power development and flood control will also result. The power plant was completed Nov. 30, 1936.

The structure, beginning at the south bank consists successively of a non-overflow section upstream from the service bay and control house, 177 ft long; eight forebays in the powerhouse section, 613 ft long; another non-overflow section, 718 ft long; 2700 ft of spillway; 1756 of non-overflow; 162 ft of lock; and a cutoff wall, 209 ft long, across the location of a possible future lock, tying the dam into the north bank. The total length of the concrete structure will be 6335 ft, and the length of the roadway that will cross the dam 6518 ft. The height of the dam is 72 ft. The control building is a five-story structure at the extreme south end of the dam.

This crane is used for handling turbine parts and is shown in position over the turbine pit in Fig. 2. Specifications were prepared by the engineers of the Bureau of Reclamation, Department of the Interior, and the Tennessee Valley Authority. Before proceeding with construction, stress diagrams were submitted, showing stresses in the crane structure and wheel loads under various conditions of loading and operation; complete detail drawings and stress computations at important points of the mechanical parts also were prepared.

DETAILS OF CONSTRUCTION

The crane span is 69 ft, center to center of runway rails. It is 52 ft from the downstream runway rail to the top of the trolley rail on the girder, and the upper runway is 28 ft above the lower one. The full-load capacity is 270 tons on the two main hooks, and this load is handled by a special lifting beam attached to the main hooks. Each trolley has an auxiliary hoist of 20 tons' capacity.

The bridge speed is 75 fpm. The speed of the main hoist is 5 fpm, and the lift is 72 ft. Auxiliary hoist speed is 33 fpm, with a lift of 85 ft, and the trolleys have a speed of 30 fpm. The wire rope required to reeve the hoists totals 5000 ft.

The power supply is 440-volt 60-cycle alternating current, delivered at mains that are carried in a covered trench which is located outside the sill of the short leg at the upstream side. The four hoist motors and two bridge motors are 60 hp, and the trolley-travel motors are 15 hp. The control is completely magnetic, the panels being enclosed and mounted on the bridge footwalks and the seven master switches conveniently ar-

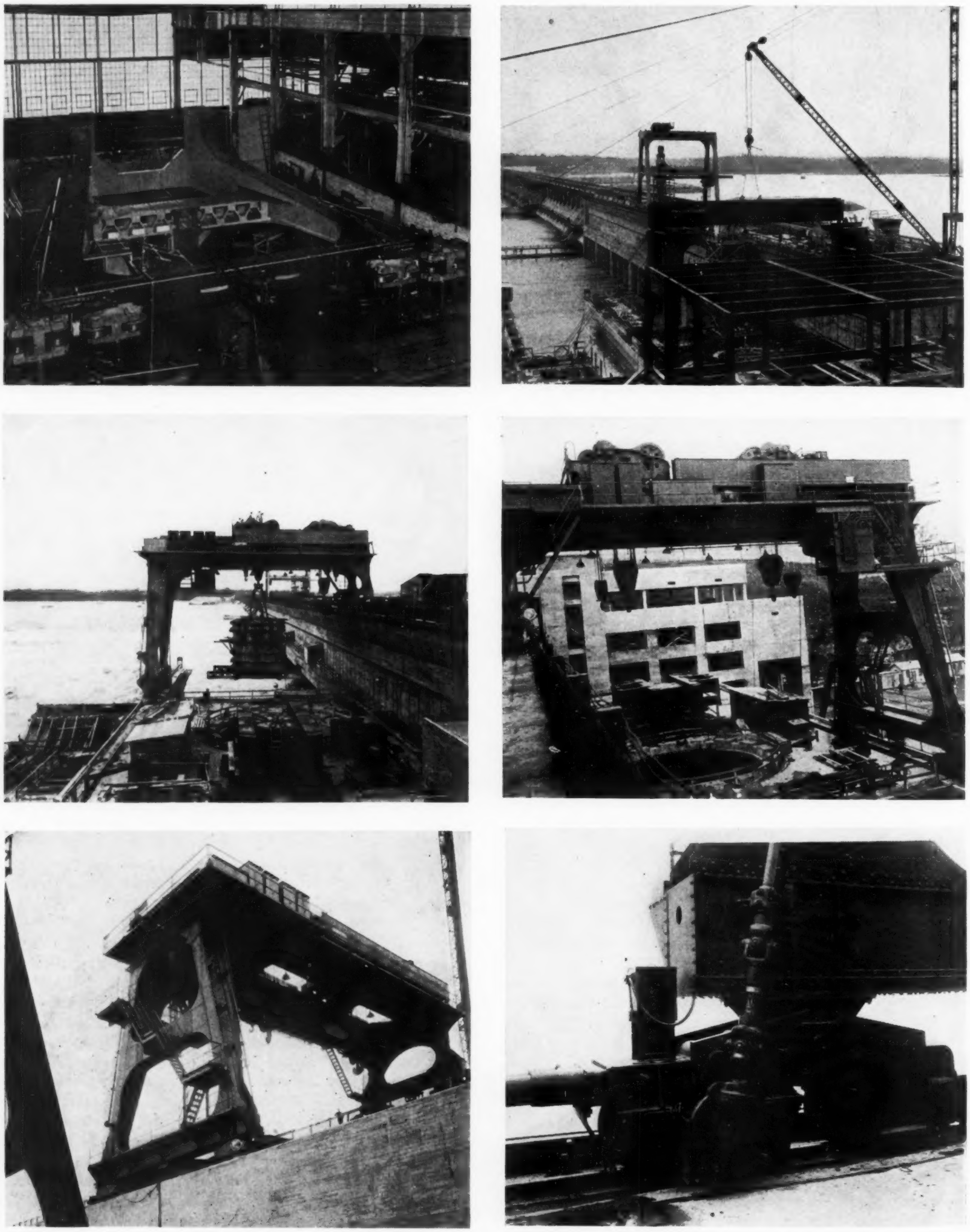


FIG. 2 VARIOUS STAGES IN ASSEMBLY AND INSTALLATION OF THE 270-TON DOUBLE GANTRY CRANE AT WHEELER DAM

(Upper left: Shop view showing one of the legs being assembled; Upper right: Placing one of the bridge girders; Center left: Crane with a test load of 170 tons applied to one of the lifting hooks; Center right: Crane in position over the turbine pits; Lower left: Looking up at the crane from the lower level; Lower right: Spur and bevel gears drive the outside wheels at each corner.)

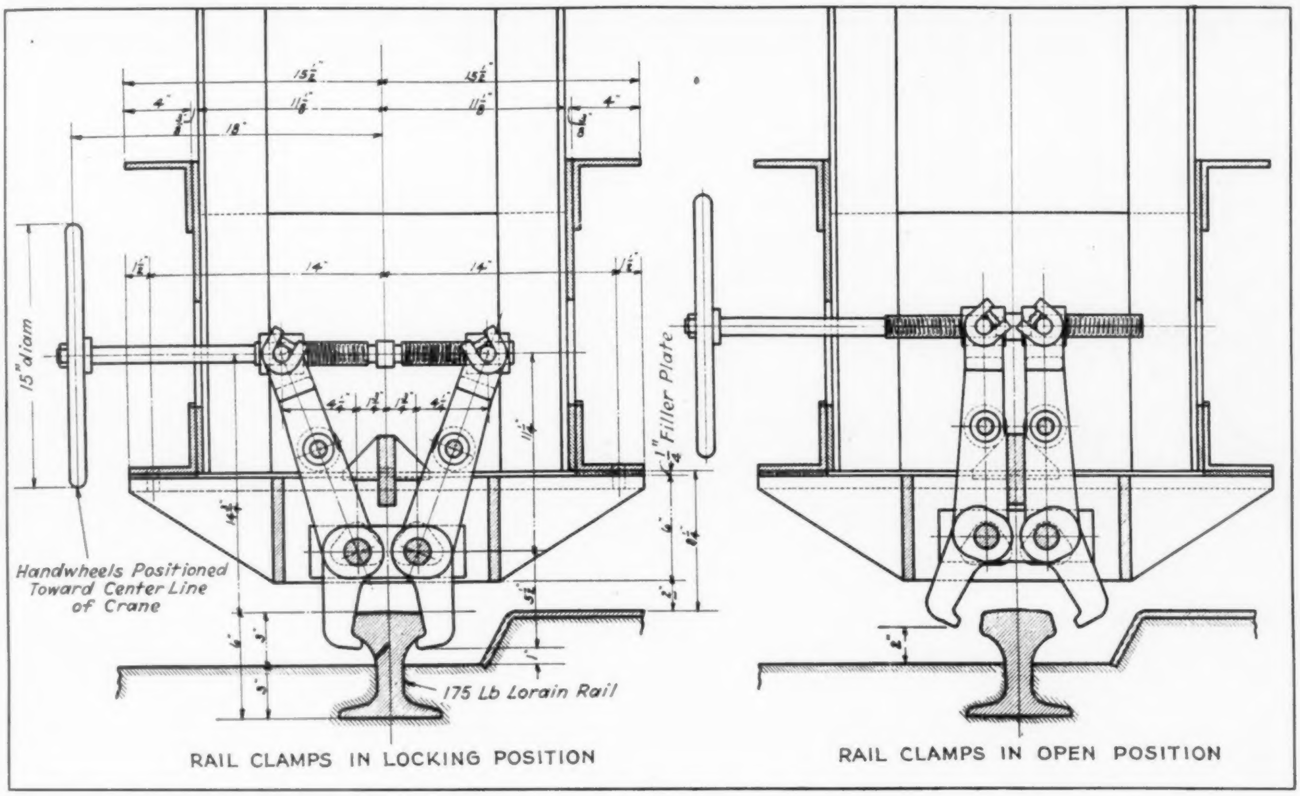


FIG. 4 SPECIAL LOCKING MECHANISMS ARE PROVIDED UNDER EACH SILL AND FOR EACH TROLLEY

ranged in the cab. Current for operating the trolleys is supplied by 2-in. angles. Forty-eight of these, arranged in double rows on the outside of each girder and a single row inside of each girder, are required.

A number of interesting mechanical features are to be found in the bridge-drive mechanism and trolleys. Each corner of the crane structure is carried on four 27-in. wheels with two equalized trucks. Under certain conditions, the wheel loads are more than 100,000 lb. The two outside wheels at each corner are driven by spur and bevel gears, as shown in Fig. 2. The equalizing beams are built of annealed plates and structural sections which are welded together. The side plates are cut from $3^1/_2$-in. slabs.

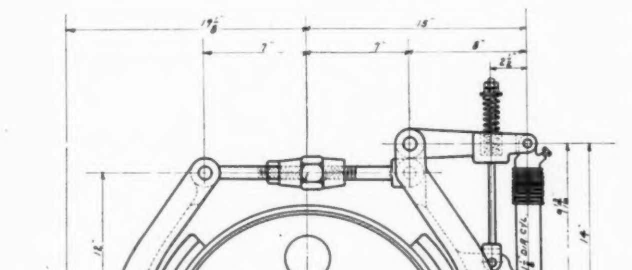


FIG. 3 EQUALIZED 20-IN. HYDRAULIC BRAKES ARE PROVIDED FOR EACH MOTOR

Each set of bridge gearing is driven by a motor mounted at the center of the bridge girder, as shown in Fig. 2, and all gearing between the motors and the drive trucks is designed to carry at least 60 per cent of the breakdown torque of the motor. Torque is delivered to the bevel pinions through a universal joint that provides for horizontal and vertical movement of the truck. The weight of each vertical shaft is carried by a roller bearing mounted under the top bevel gear. Solid-type bronze bushings are used on this crane. All exposed ends of bearings are provided with oil seals to retain lubricant and exclude dust. Each bridge motor has a 20-in. hydraulic brake. The two brakes are equalized and operated from the cab. (Fig. 3)

SPECIAL LOCKING MECHANISM FOR CRANE AND TROLLEY

Under each sill, a locking mechanism, illustrated in Fig. 4, is provided. These are designed to hold the unloaded crane against a wind pressure of 30 lb per sq ft and also to clear the runway when unclamped.

Each trolley is driven by a 15-hp motor which is geared to two driving wheels and has an electric armature brake. Each trolley is also provided with a locking device which clamps to the trolley rail and will withstand a wind pressure of 30 lb per sq ft. Each hoist is provided with an electric armature brake with a capacity equal to $1^1/_2$ times the full-load torque of the motor and also with a mechanical disk-type load brake, which prevents lowering of the load unless the hoist motors are operating under power in that direction. Each main hoist has 20 parts of $1^1/_8$-in. wire rope and each auxiliary hoist, 8 ropes $^3/_4$ in. in diameter.

Complete assembly of the crane structure in the shop was not

feasible. However, the connections were designed and laid out in the shop so that all adjacent parts were assembled together with the center lines established and all corresponding holes reamed in place. Fig. 2 includes a shop view showing part of the structure being assembled. In the field, all these connections lined up for bolting and riveting.

Considering the analysis of loading or stresses in the crane structure, except determining the tractive forces affecting bridge-wheel loads and stresses in gantry legs and bumpers, is outside the scope of this article. In determining these forces, the specifications required that they consist of 10 per cent of the weight of the bridge structure and its machinery, which is applied at its center of gravity, and 10 per cent of the weight of the loaded trolleys, which is applied at the top of the trolley rails.

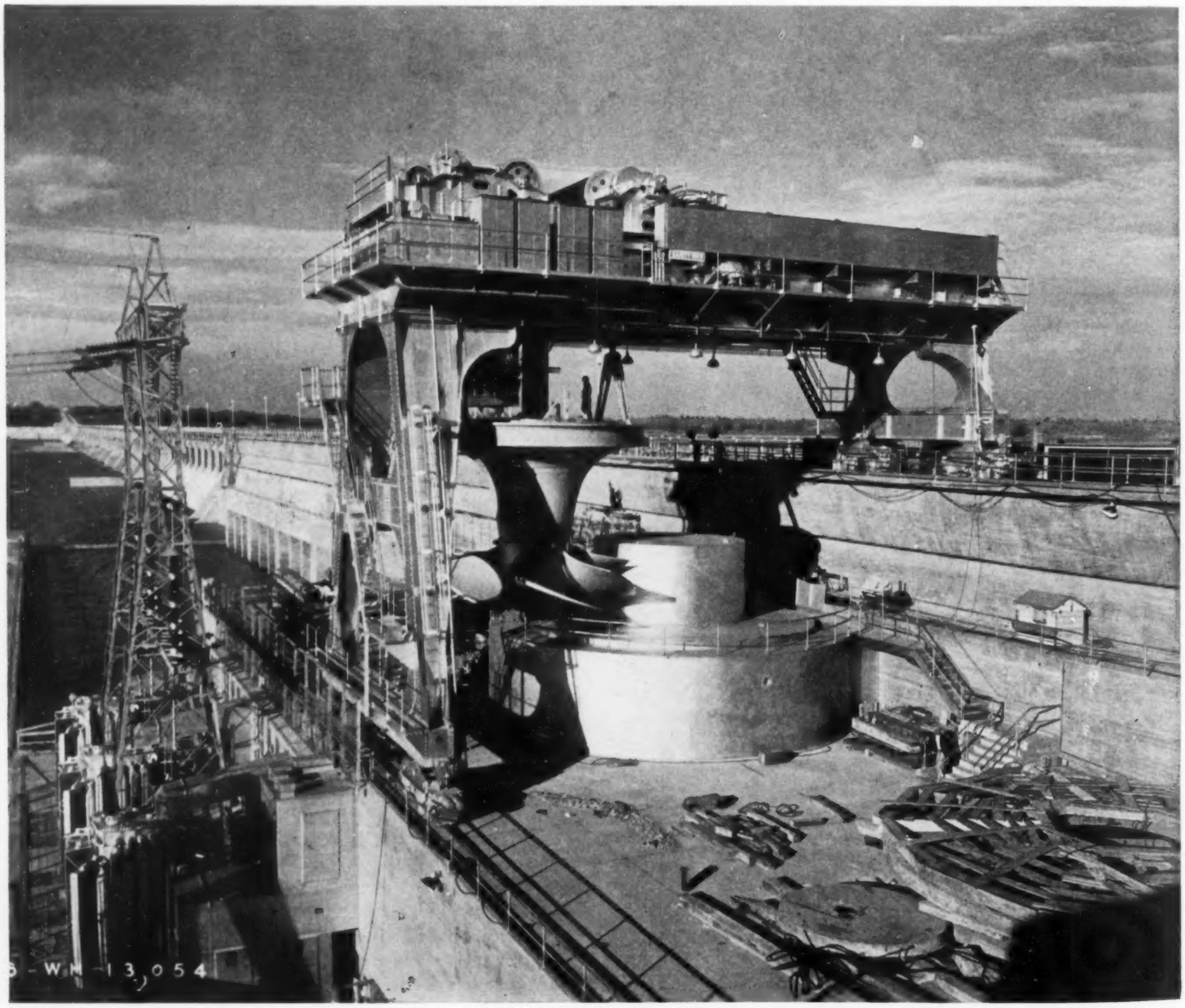
SUSPENDED LIVE LOAD ABSORBS SHOCKS

The effect of the suspended live load on the tractive force is considered as follows: Suspending the load has the effect of lowering the center of gravity of the inertia forces and reducing the overturning moment which induces internal stresses and adds to the maximum wheel loads. This suspension has somewhat the effect of a shock absorber. The approximate effect of this application of loading is described in the following analysis.

The center of gravity of the suspended load was taken at 15 ft below the point of suspension. The swing of the load until the bridge stops will be less than 3 in. During this swing, however, the point of suspension has moved forward $1^1/_2$ in. in coming to rest, so that the load is then less than $1^1/_2$ in. out of the vertical. In short, the major portion of the kinetic energy of the live load will be absorbed by the structure after the crane has stopped and the inertia stresses from the moving bridge have died out. The effect on the bumper springs at the end of the bridge runway is similar. The suspended load adds very little to the compression of the bumper springs but tends to check the rebound.

When the crane was operated under test load, the operator was able to lower the load and stop it by amounts as small as $^1/_{16}$ in.

The designing of the crane was done under the direct supervision of G. W. Yanney, chief engineer of the Alliance Machine Co. E. H. Windolph, structural engineer, was in charge of the structural part of the design.



GENERAL VIEW OF WHEELER DAM SHOWING THE 270-TON GANTRY CRANE

RAILWAY LUBRICANTS

Possibilities for Their Standardization

By B. F. HUNTER

GULF OIL CORPORATION, PITTSBURGH, PA.

FOR A clearer understanding of the characteristics of railroad lubricants, a brief discussion of petroleum, petroleum refining, and petroleum lubricants, from the manufacturers' viewpoint, is important. Although petroleum in its crude state may vary widely in certain characteristics from one field or one pool to another, and from one depth of well to another, the greatest, and perhaps the most important difference in petroleum is in the molecular structure of the hydrocarbon. This divides petroleum into two general classes, (*a*) paraffin base and (*b*) asphalt base. The former class of crude petroleum yields paraffin wax when refined, and the latter or naphthene crudes do not yield paraffin wax but an asphaltic type of material.

To recommend the most stable lubricant for a specific purpose, the engineer should have a thorough knowledge of petroleum, its characteristics, and its manufacture. In recent years, some of the more common properties of petroleum, such as gravity, viscosity, flash, fire, and pour test, have become more generally understood, which has resulted in many of the larger consumers of petroleum products purchasing according to their individual specifications. In many instances, such specifications fail completely to select the most stable, suitable, or efficient product for each specific purpose. Petroleum lubricants purchased or sold to meet a specification places the burden of performance or suitability on the shoulders of the purchaser. Specifications, from different purchasers, for a lubricant for a specific purpose vary widely and compel the manufacturer, in many instances, to provide a special product to meet the specifications, thus placing a generally higher manufacturing cost on his shoulders. Specific examples are more or less generally described in the following pages.

CAR LUBRICATION A UNIVERSAL PROBLEM

The design of car journals and the method of their lubrication on the many railroads vary but little, and interchange of cars from one road to another is very general. The lubrication of car journals, therefore, should be considered a universal problem that is common to all railroads. From the lubricant manufacturer's or the lubrication engineer's viewpoint, however, this is not the case since a wide difference is found in the specifications or physical characteristics of the car oils demanded by the various railroads. A wide difference in climatic conditions encountered by railroads operating in the northern and southern parts of this country does exist, but we are confronted with the interchange of cars and, obviously, much can be said in favor of a universally standard car oil. The many lubricating problems encountered in the operation of railway cars is common knowledge and of common interest to at least the refiner and the marketer, lubricating engineers, and the operating personnel of the railroad. Recently, much progress has been made in the lubrication of railway cars, but we are constantly being confronted with severer conditions resulting from higher speeds and heavier loads, with resultant higher bearing pressures, and the general desire and demand of the railroads for uninterrupted service resulting from fewer hotboxes. Faster and more reliable passenger and freight schedules are constantly being adopted, and what the future will demand cannot be foreseen. Attributing a hotbox or journal failure to any one definite cause is difficult. Some of the major contributing factors are: Improperly fitted brasses; tapered journals; insufficient oil at high speeds due to the method of lubrication or the packing settling away from and not contacting the journal; excessive water in the box; dirt, solids, or abrasive matter in the packing; waste grab due to viscosity or tenacious character of the oil at low temperatures; and improper packing.

Corrective and properly supervised operating practices that will improve these physical factors will unquestionably result in minimizing the number of hotboxes. Although hotboxes cannot be completely eliminated by adopting and using a specific type or quality of lubricating oil, nevertheless, within certain definite limits of physical properties, some possibilities of improving the situation do exist.

IMPORTANCE OF POUR TEST EXAGGERATED

For years, the pour test of a car oil was a characteristic prominently mentioned or demanded by railroads and recommended by most marketers as a characteristic inherent in a so-called winter car oil. The theory that a low pour-test oil would minimize the tendency for waste grab at low temperatures was generally accepted. Pour test and viscosity or tackiness are not relative. A typical specification for a winter car oil was a Saybolt Universal viscosity of 250 to 400 sec at 100 F, and from 40 to 50 sec at 210 F, with pour test from 0 to —15 F.

Summer car oils were of similar characteristics but relatively higher in viscosity. To provide a car oil that met these specifications or characteristics and could be sold at the prevailing prices obtainable for such an oil, they were usually manufactured from crudes of the naphthenic series. Naphthenic oils were free from paraffin wax and could be manufactured and sold at lower prices than oils of similar viscosity and low pour test from crudes of the paraffin series.

Temperatures below 0 F are not uncommon in the northern portion of the United States and in Canada during winter months. Winter car oils manufactured from naphthenic crudes to meet the specifications previously mentioned may have Saybolt Universal viscosities at —15 F in excess of 500,000 sec. Waste grab at low temperatures may, therefore, be expected when the viscosity of the oil runs into the thousands. When these factors are fully appreciated, the importance of cold test in winter car oils may be questioned.

Improved refining practices now permit car oils with a 0-F pour test to be produced from crudes of the paraffin series at a price slightly in excess of the market price of car oils manufactured from crudes of the naphthene series.

Operators not familiar with the low-temperature characteris-

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tics of oils manufactured from crudes of the paraffin series may question the 0-F pour test. Paraffin oils, unlike the naphthenic, are less viscous and tenacious at low temperatures and the tendency to waste-grab is much less pronounced. Paraffin-type oils will take a definite set or will become solidified at temperatures below the pour point, and this characteristic may be considered a virtue in that it will have a certain tendency to hold fine particles of waste or packing and prevent them from being carried under the journal brass. In recent winters, paraffin car oils have been used by some major railroads with a marked reduction in the number of hotboxes attributed to waste grab at extremely low temperatures. In laboratory tests, journal boxes have been set up to simulate service conditions, and the behavior of different types of oil at low temperatures was observed. These experiments demonstrated conclusively that waste grab with naphthenic oils occurred at temperatures approximating 0 F, whereas, with paraffin oil of certain definite physical properties, waste grab was prevented at temperatures of —50 F. The viscosity-temperature curve, or the viscosity index, was an outstanding characteristic in classifying the tendency toward waste grab with different types of oil. The minimum of waste grab may be expected from an oil having a viscosity index of at least 100. Many prominent railroads are now buying car oils under specifications with a viscosity index of 0 and lower. With a paraffin oil having a viscosity index of 100, waste grab should not occur at temperatures down to —40 F. Such oils can be provided with a 0-F pour test at a cost slightly higher than similar-viscosity oils manufactured from crudes of the naphthene series. This oil should be adopted as a universal or all-year car oil by all railroads.

For the summer months, or on railroads operating in the southern part of the country where atmospheric temperatures are somewhat higher, better lubrication can be expected from this oil. By virtue of the flatter viscosity-temperature curve, higher viscosities are obtainable at higher temperatures and lower viscosity at lower or atmospheric temperatures. This will result in a more copious supply of oil being fed from the packing to the journal at higher speeds with resultant better lubrication and fewer hotboxes.

In the winter of 1935–1936 long periods of low temperatures were encountered on northern railroads, and a pronounced increase in hotboxes or journal failures resulted. We hope that some of the larger northern railroads will, at least, adopt the proper paraffin type of all-year car oil for their passenger equipment for the coming winter and prove its merits or demerits by actual operation. If such a program can be formulated and tried, precautionary measures, within reasonable limits, should be taken to eliminate, as far as possible, some of the other major contributing factors that have already been mentioned.

CENTER-PLATE LUBRICANTS AND BRAKE-CYLINDER LUBRICATION

A universally standardized lubricant for center plates should be beneficial alike to both railroads and suppliers of lubricants. Lubrication of a center plate possesses no marked differences, whether operating in the north, south, east, or west, but a wide difference is found in the specifications of the various railroads for center-plate lubricants. Graphite greases, that is, petroleum oils containing various percentages of graphite, are specified by some roads, viscous asphaltum oils are specified by others, and still others prefer an oil of the steam-cylinder type. In some instances, various types of medium soft grease are specified. The best lubricant would no doubt be a viscous oil containing graphite.

The common practice is to lubricate air-brake cylinders with a medium-soft calcium-soap grease with or without added graphite. A grease of this type will resist the action of water or moisture from condensation and will be stable for a long time. Ordinary calcium-soap greases are entirely satisfactory for the lubrication of brake cylinders at normal temperatures; however, in the winter months with their low atmospheric temperatures, sluggish action of the brake mechanism results from the lubricant's increased viscosity.

Adoption and universal use of a special lubricant of a plastic nature similar to grease which will permit freer movement of the brake mechanism at low temperatures offers possibilities of decided improvement in brake-cylinder lubrication. An ideal brake-cylinder lubricant would be a soap-free plastic material, as formation of gummy deposits created by the oxidation of the soap content in the lubricant will be less. This lubricant can be provided at a nominal cost.

INCREASED SPEEDS, PRESSURES, AND TEMPERATURES COMPLICATE STEAM-CYLINDER LUBRICATION

In the earlier days, the lubrication of steam cylinders was not as great a problem as it is today. Increased speeds, greater steam pressures, higher temperatures, and bad water conditions have all contributed their part toward a more severe and difficult lubricating problem. Valve oils are viscous petroleum oils manufactured from crudes of the paraffin series and are usually compounded with from 4 to 8 per cent of fixed or fatty oils, such as tallow oils, lard oils, etc. They are fed by lubricators directly into the steam line and are carried by the steam to the working parts of the valves and cylinders or in some instances fed directly to the valves or cylinders. Bad boiler feedwater, that is, water containing impurities, has a decided effect on cylinder lubrication. The higher the percentage of impurities in boiler feedwater carried over to the cylinders, the greater will be the deposits in the cylinder, usually referred to as carbon deposits. The only recourse the refinery has to improve this condition is filtration. Filtered valve oils will minimize the formation of deposits resulting from bad water. The higher the steam temperatures, the greater will be the tendency to form deposits on the valves and cylinders and, only by filtering the valve oils and removing the tarry or gum-forming hydrocarbons, can this condition be improved. Filtered valve oils have been available only during the more recent years and their general adoption would undoubtedly improve steam-cylinder lubrication. Superheated steam and the high steam temperatures naturally brought new lubricating problems to the railroads; however, they are more common with all roads today, and satisfactory superheat valve oils are generally available. Specific cases require special consideration and special lubricants, possibly.

Low-pressure or saturated-steam locomotives do not offer the lubricating problems encountered with superheat and high-pressure steam. Valve oils that are lower in viscosity should be used. Saturated valve oils are usually not so well refined as the tendency toward the formation of deposits is not as pronounced. Washing effect and lower steam temperatures tend to keep valves and cylinders free from deposits.

Operating conditions of a superheated locomotive or a locomotive employing low-pressure saturated steam do not differ widely from one road to another, and a more universal specification for superheat and saturated valve oils should be adopted. Most railroads purchase their valve oils under their own specifications which vary rather widely from one road to another, and the manufacturer and the supplier of lubricants is called upon to supply many grades of valve oil to meet the various specifications, which, from the refiner's viewpoint, or, in reality, do not require any special characteristics. Refiners

frequently have as many as 15 or 20 different valve oils that may vary slightly in viscosity, compound, gravity, or other special properties, and yet not one of them may meet a particular specification.

The proper application of a valve oil to the valves and cylinders, in many instances, has a more direct bearing on the results obtained than the particular type of oil. Valve oils, when fed into the steam lines, should be properly atomized so that the steam can distribute the oil evenly over all rubbing surfaces. The importance of proper atomization of valve oils is frequently neglected or overlooked entirely. A universally adopted specification for a superheated and a saturated valve oil should prove equally beneficial to both the railroads and the manufacturers and suppliers of lubricants.

Lubrication of air-compressor cylinders is very different from the lubrication of a steam cylinder. Air does not have the same washing effect on the oil as steam; therefore, a different oil and a smaller quantity of oil should be used.

For years, common practice has been to use the same oil for lubricating the cylinders of the air compressor as the steam end of the compressor, due, perhaps, to the type of lubricator employed and the general desire to use fewer oils. This fault is being generally recognized, and steps are being taken to provide a separate lubricator for the air-compressor cylinders so that the proper oil will be used.

DRIVING-JOURNAL COMPOUND AND ROD-PIN GREASE

Locomotive driving-journal compounds and rod-pin greases are a mixture of high-viscosity mineral oil manufactured from paraffin crudes and from 40 to 50 per cent of soap. Sodium soaps are usually employed because they provide a higher melting-point grease than those of similar consistency which are manufactured from calcium soaps. Discussing the application of these lubricants is not necessary, since every one is familiar with this practice. In the manufacture of petroleum greases, various percentages of soap are added to the oil; the greater the percentage of soap, the harder will be the grease and the higher the melting point. To provide a driving-journal compound or rod-pin grease of the correct consistency or hardness to function properly under the method of application, from 40 to 50 per cent of soap must be used. Soap, itself, is not a lubricant, and the lubricating value must come from the mineral-oil content. The melting point of locomotive driving-journal compound and rod-pin grease by the usual test methods will generally be in excess of 325 F.

Driving journals and rod pins must, therefore, by necessity, operate at abnormally high temperatures to melt the grease. Such temperatures result from friction and are not encountered on similar bearings where lubricating oil free from soap is fed directly to the journal or bearings. Lubrication resulting from high-melting-point, hard greases that are held against the journal cannot be expected to provide the most effective or ideal lubrication. Why greases of this character were originally adopted for the lubrication of locomotives may be questioned, but the practice, however, is universal, and locomotives can operate in this manner.

Straight oil-lubricated locomotives are being adopted and experimented with by several railroads in this country with considerable success, but this practice has been more extended in Europe than in America. Hard greases, usually referred to as block greases, were common for many years in industry for the lubrication of heavy-duty bearings, but this practice is now practically extinct. Oil applied by a circulating system has proved far more satisfactory and efficient. Recently, the operation of locomotives has been extended over several divisions. This practice, as well as higher speeds, has made lubrication more severe, and operators generally recognize this fact. With the increased speeds and greater mileages, a lubricating condition beyond the physical limits of greases may have been created, and future locomotives may be designed for proper oil lubrication.

Driving-journal compounds and rod-pin greases, like most common railway lubricants, are usually purchased according to specifications that usually limit the viscosity of the mineral oil used, the percentage of soap content, the kind of soap, and the penetration or consistency of the grease at a given temperature. These specifications vary from one purchaser to another in several minor details, which are usually of such a nature that a special product must be supplied. Actual conditions between one road and another are not so widely different, and a universal specification for driving-journal compound or rod-pin grease could be adopted and would prove entirely satisfactory.

Viscosity of the oil used in the manufacture of these lubricants is an important factor. The consistency or penetration of the grease at the working temperature is likewise important. They are usually taken at 77 F which does not represent the working temperatures, and, although a specific grease may meet the specification for penetration at this temperature, it may be considerably harder or softer at the actual working temperatures than another grease with similar penetration at 77 F. A more universally satisfactory grease, therefore, might be obtained if consistencies of the grease were based on temperatures nearer those of actual operation. Too soft a grease at the working temperatures will result in excessive consumption, although too hard grease will not lubricate until higher temperatures are developed by excess friction.

Operation of the railroads has reached a point beyond the physical possibilities of hard greases as lubricants. Limitations to the satisfactory performance of a specific lubricant or type of lubricant do exist, and, if these have been reached, future progress may rest with designers and builders of rolling stock.

Lubricants specified and demanded for hub liners vary from viscous oils to greases because operators differ regarding the proper type. Actual differences in results obtained from lubricants in many cases are due to application. Regardless of how well suited a specific lubricant may be, poor results are to be expected if it is not properly applied. Standardized hub-liner lubricant and standardized application practices should prove economical to both consumer and producer.

ELECTRIC LOCOMOTIVES PRESENT SPECIAL PROBLEMS

Ball and roller bearings with grease lubrication are commonly used in electric locomotives. Their lubrication is a somewhat special condition, and the proper grease depends upon temperatures, speeds, and method of application. These problems have been given serious and careful consideration by the manufacturer of the equipment, the manufacturer of the lubricants, and the operating personnel, and, in general, the lubricants furnished can be considered fairly satisfactory. Further study with reference to more stable greases is being considered by the larger refiners, and the investigation is expected to result in more satisfactory and stable lubricants.

The lubrication of the gear teeth is perhaps a more serious and difficult problem than is encountered in bearing lubrication. The high peripheral speed of the gears has a tendency to throw lubricant off the teeth. The only recourse left to the manufacturer is to provide a tenacious lubricant that will adhere to the gear teeth at high speeds. Under such conditions, the lubricant must be applied directly to the teeth, and cannot be depended upon for bath lubrication. The high revolving speeds of the gears throw the lubricant to the sides of the sur-

rounding case, where it adheres and does not flow back to the bottom of the case for recontact on the gear teeth. Where the gear cases are not sufficiently tight to hold a more fluid lubricant, high-viscosity lubricants must be used, and frequency of application determined by careful observation of the gears.

Where the gear housings are oiltight and a more fluid lubricant can be retained, better lubrication will be obtained by keeping the level of the lubricant at a point where the teeth of the revolving gears can dip into it. This method is generally referred to as splash lubrication, and lubricants of the proper viscosity and sufficient fluidity to drain or run back to the bottom of the gear case readily, at the lowest temperature encountered, should be used.

DILUTION AND GUM FORMATION IN DIESEL-ENGINE LUBRICATION

High temperatures and continuous use of lubricating oil in a Diesel engine demand that only the highest grade be used. Dilution and the formation of gummy or tarry deposits, sludge, and carbon are the problems most commonly encountered in Diesel-engine lubrication.

Dilution is a direct result of unburned fuel entering the crankcase or lubricating-oil system. No lubricating oil, regardless of its degree of refinement, will resist dilution; a diluent will affect one oil as readily as another. Diluents, or unburned fuels, quickly destroy the body of the oil and its lubricating value. Dilution is a problem of combustion and usually results from incomplete combustion of the fuel. Improper combustion cannot be corrected by a lubricating oil.

Gummy deposits and the formation of deposits in the crankcase or in the lubricating oil of Diesel engines may result from several sources. Diesel-engine lubricating oil is subjected to the oxidizing influences of the high temperatures and continuous agitation in the presence of air.

All petroleum oils will oxidize to a greater or less degree. Highly refined and specially refined Diesel oils will resist oxidation more successfully than less refined or improperly manufactured oils. The products of oxidation are gums, sludge, and carbon. Carbon or gummy deposits found in the crankcase are frequently a product of the unburned fuel and wrongly blamed on the lubricating oil. If partially burned fuel, which is highly oxidized, is permitted to contaminate the lubricating oil as a result of improper combustion, improperly fitted or worn piston rings, and the like, the lubricating value of even the finest oil will be seriously impaired. To insure the most satisfactory performance, Diesel engines should be kept in good mechanical condition and provided with properly designed and operated oil filters to remove oxidized oil, sludge, partially burned and oxidized fuel, carbon, and dirt particles. Filters will not, however, remove dilution.

Lubricating oil that has been diluted with unburned fuel is usually referred to as having broken down or thinned out. It does not thin out in service but rather increases in viscosity due to oxidation. When lubricating oil has actually become thinner in service, this condition can be directly and definitely attributed to contamination by unburned fuel. The Diesel engine is an internal-combustion engine, and, when proper combustion exists, little difficulty will be experienced in its operation or in the formation of carbon or the dilution of the crankcase lubricating oil. Improper combustion and partially burned fuel will quickly result in the formation of excessive carbon, rapid dilution of the lubricating oil, and excessive wear of moving parts. Excessive carbon formation in the combustion chamber, on the piston head, behind the piston rings, and in the crankcase lubricating oil, which is generally attributed to the lubricant, is, in most cases, directly traceable to incomplete combustion of the fuel.

Signaling and switch-actuating mechanisms play an important part in railway operation. They are subjected to the effects of variable temperature conditions, extremely low temperatures, perhaps, offering the greatest problem from the lubricating standpoint. Signaling mechanisms on northern roads are frequently subjected to temperatures far below zero. Low pour test is, therefore, considered the factor of greatest importance. One oil in general use has a Saybolt Universal viscosity of approximately 80 sec at 100 F; however, at temperatures of —25 F, which is not uncommon on northern railroads, the viscosity would be in excess of 10,000 sec. Pour test, therefore, is not the factor governing the proper oil for the lubrication of signaling mechanism at low temperatures. The viscosity or the tackiness of the oil or lubricant at low temperature is of more consequence. Lubrication with a grease or plastic material is possible and practicable.

Paraffin-type oils, with their widely different characteristics at low temperatures, are worthy of serious consideration by the signaling departments of the railroads. Last winter, tests and experiments were made on at least one of the major railroads with paraffin-type oils. No doubt a report of the results obtained will be available later.

LUBRICATION OF SWITCH-ACTUATING MECHANISM

The electrical switch-actuating mechanism, familiar to all railway operators, presents an important lubricating problem at low temperatures, and, in extremely cold weather, men must be assigned to operate the switches manually, because the lubricant commonly used and recommended for the gear case becomes so viscous at low temperatures that the motor could not actuate the mechanism. Liquid or soft greases, commonly referred to as semifluid oils or liquid greases, are generally recommended. The characteristics of a semifluid oil or a straight mineral oil at low temperatures depends upon the type of crude from which it is manufactured. A low pour-test paraffin-type oil was demonstrated last winter in a switch-actuating mechanism, and, by actual measurement of the current required to actuate the switch, paraffin-type oil of the proper viscosity was found to be far superior to semifluid oils or low pour-test oils of the naphthene series. These results may appear strange to those who are not familiar with the characteristics of petroleum lubricants at low temperatures, and those responsible for operating signaling mechanism at low temperatures should investigate the superiority of the proper viscosity, low-pour-test paraffin oil for this service.

The desirability of flange lubricants for rail flanges, sharp curves, and similar locations is fast being appreciated. Many ingenious flange lubricators have been perfected and are being demonstrated. In most instances, a lubricant is selected to perform satisfactorily in the particular type of flange lubricator. Rather than adopt the lubricant best suited for the flange lubricator, the type and character of lubricant that is the most effective for lubricating flanges should first be determined. When this fact has been definitely determined and agreed upon, flange lubricators should be provided which will apply the proper lubricant at the maximum low-temperature conditions. Little difficulty is experienced in the operation of flange lubricators at normal atmospheric temperatures. Perhaps the most satisfactory lubricant for flange lubrication is a medium-viscosity mineral oil with from 10 to 30 per cent of graphite added.

Cooperation between railroad companies and manufacturers of lubricants has resulted in a more common knowledge of important problems. The larger refiners and marketers have lubrication engineers trained in railway problems, and the major railway companies have specialists trained in lubrication.

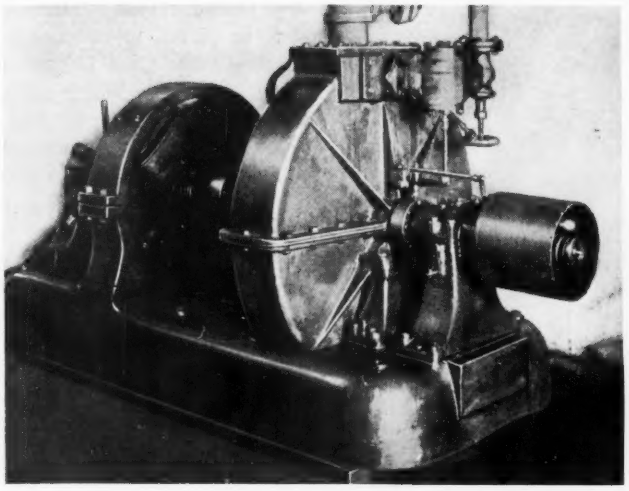


FIG. 1 SINGLE-STAGE CURTIS TURBINE CONNECTED TO ELECTRIC GENERATOR, 1900

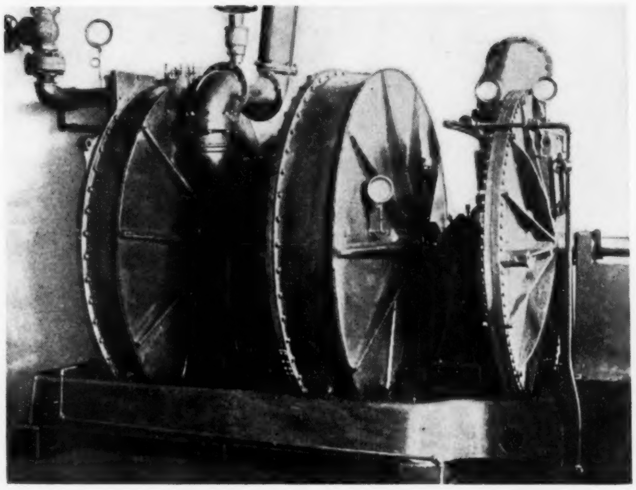


FIG. 2 200-KW, TWO-STAGE CURTIS TURBINE CONNECTED TO WATER BRAKE, 1900

The STEAM TURBINE *in the* UNITED STATES

III—Developments by the General Electric Company

By ERNEST L. ROBINSON

TURBINE ENGINEERING DEPARTMENT, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

IN 1897, the General Electric Company entered into an agreement with the inventor for the exploitation of the Curtis steam turbine. The basic patent No. 566,969, subsequently upheld by the courts, provided for pressure staging, using the impulse construction with one or more rows of moving buckets, the latter feature constituting velocity compounding of the individual stages. As the practicability of the invention became more evident, negotiations were carried on with a view to organizing for the manufacture of Curtis steam turbines on an extensive scale. E. W. Rice, then vice-president in charge of manufacturing and engineering, represented the General Electric Company in these transactions.

It was originally intended that the manufacture would be handled by a separate organization to be known as the General Turbine Company, which would be financed by the General Electric Company, and the main agreement for manufacture was drawn up on this basis in 1902. The following year, however, the idea of a separate company was dropped, and the General Electric Company undertook the manufacture itself.

The application of Curtis turbines to marine and aerial propulsion was reserved for a separate organization by the Curtis Company, but the rights to manufacture electric drive for all purposes were secured for the General Electric Company in the main agreement. This arrangement provided for turbine-electric drive of ships, E. W. Rice being credited with the vision to add this provision.

Contributed by the joint Division on Engineering History and the Power Division and presented at the Annual Meeting, Nov. 30–Dec. 4, 1936, of The American Society of Mechanical Engineers.

Following the earliest agreement in 1897, the General Electric Company proceeded immediately to exploit the ideas of the inventor, and built and tested in its factory at Schenectady during the next five years a number of experimental machines. Two such turbines were photographed in March, 1900. Fig. 1 shows a single-stage machine driving an electric generator, and Fig. 2 a 200-kw, two-stage machine connected to a water brake. These early turbines had horizontal shafts, and a great many analytical tests were run on them. For example, in August, 1899, and again in March, 1900, rotation-loss tests were run on a three-stage machine having disk diameters of 17.5 in. In this turbine all three wheels were in a single casing. Other wheel and bucket combinations were run throughout 1901 and 1902 under the supervision of A. R. Dodge to determine the fundamental design characteristics of impulse nozzle and bucket performance. A gas-fired superheater was built and used in these tests.

Up to 1900, these developments were directed by the inventor, Charles G. Curtis, and his whole hearted cooperation was an invaluable contribution to the success of his ideas.

In 1901, W. L. R. Emmet was assigned the responsibility for exploiting the Curtis turbine, and it is not too much to say that the whole project might subsequently have been abandoned except for his zeal. Mr. Emmet's responsible connection was maintained for a dozen years throughout which time Curtis rendered all possible help and cooperated with Emmet to the utmost.

The first 500-kw turbine was designed under Emmet's direction in 1901, and it was at this time that he sought the as-

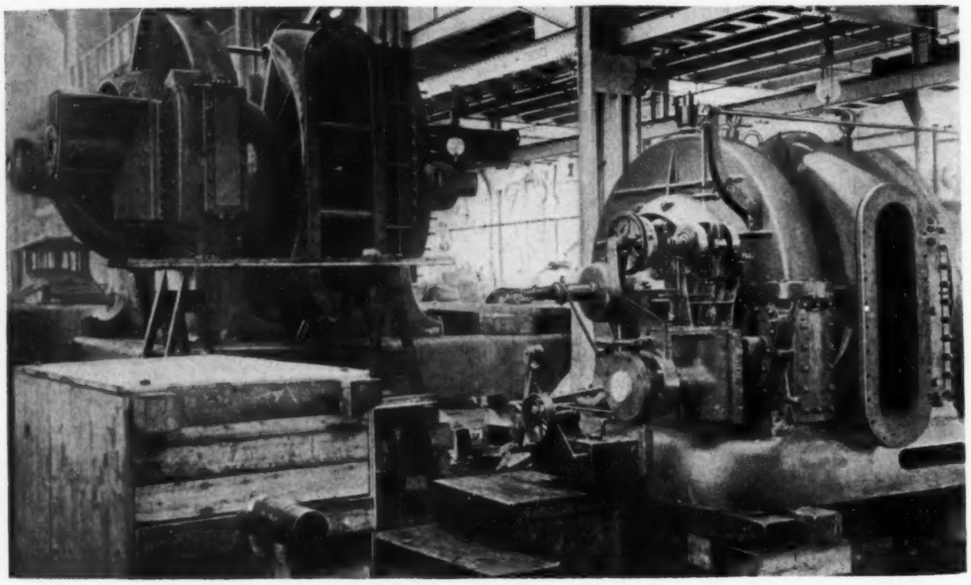


FIG. 3 AT LEFT, 1500-KW, 720-RPM, TWO-STAGE CURTIS TURBINE FOR PORT HURON LIGHT AND POWER COMPANY; AT RIGHT, 500-KW, 1200-RPM, TWO-STAGE MACHINE FOR LYNN WORKS, GENERAL ELECTRIC COMPANY, 1902

sistance of Oscar Junggren. This turbine was of a horizontal type and had two multiple row wheels in separate casings.

The crossover pipe below floor contained a baffle and a separator connection which constituted more than simple interstage drainage. The arrangement is suggestive of the provisions for moisture removal emphasized by many designers 30 years later. This turbine was placed in operation in Schenectady in November, 1901, and began regular service early in 1902. It was a two-stage machine rated 500 kw at 1200 rpm, and was in continual daily use in the shop plant at Schenectady driving an alternating-current generator and operating in parallel with water-wheel-driven generators at Mechanicsville. A similar machine was built and shipped to Lynn for direct-current generation and a larger 10-pole set of the same layout but rated 1500 kw at 720 rpm was built in 1902 and shipped in January, 1903, to the Port Huron Light and Power Company, later a part of the Detroit Edison system. Fig. 3 shows the two machines just referred to in the factory in July, 1902.

VERTICAL TURBINES

In 1902, vertical turbines were in manufacture for ratings of 500, 1500, and 5000 kw.

This development was under the inspiration of Mr. Emmet, who describes his participation in this work in chapter 8 of his book, "The Autobiography of an Engineer,"[1] in which he says:

> At the rate of growth which the electrical industry was assuming it was obvious that large units were desirable and I determined to build a turbine as large as the largest engine. The largest engines had been developed to run the 5000-kw generators for the Manhattan Railway in New York and I planned on this size. I had successfully devised a method of testing the vertical-shaft Niagara Falls generators in Schenectady, supporting the weight by oil pumped at high pressure under the end of the shaft. This had established to my satisfaction a principle in which I felt confidence and I saw that with such conditions of speed as we had in mind for the Curtis turbines a vertical-shaft arrangement would accomplish many simplifications and would save space and cost.

[1] By William Le Roy Emmet, Fort Orange Press, Albany, N. Y., 1931.

The first vertical turbine to be placed in commercial service was rated 500 kw at 1800 rpm. It was shipped in February, 1903, to Newport, R. I., for the Newport and Fall River Company, later the Bay State Street Railway Company. This was followed closely by the 5000-kw Chicago turbine which was steamed in the factory in March, 1903, and placed in service later that year. See Fig. 4.

REPORTS

The importance in which this whole matter was viewed at the time is well reflected in the 100-page reports on the Curtis turbine by W. E. Shepard in July, 1902, prepared for submission to associated foreign companies, and by W. J. Clark in February, 1903, for the president, Charles A. Coffin.

Prof. J. E. Denton, of Stevens Institute of Technology, Hoboken, N. J., came to Schenectady to witness tests, and reported figures, on Aug. 24, 1900, which closely confirmed the results obtained by A. R. Dodge. At a boiler pressure of 150 lb per sq in., 27.7 in. of vacuum, and 4500 rpm, the test turbine developed 272.3 bhp with a dry-steam consumption of 15.12 lb per bhp-hr. Professor Denton reported the best average economy of high-speed condensing reciprocating engines of similar or greater horsepower to be 19.7 lb of dry steam per bhp-hr. He concluded, therefore, that "the economy of the turbine is decidedly superior to that of this class of engines." In comparison with slow-speed Corliss-type compound engines, Professor Denton found the Curtis turbine, in its present small dimensions, to afford practically the same economy as the best reciprocating engines used for electric work.

F. W. Dean and Charles T. Main, of Boston, also witnessed similar tests in November, 1900, and admired the governing apparatus.

STEINMETZ' THEORIES

From our perspective thirty years later it is interesting to note that during the next few years Charles P. Steinmetz prepared a dozen reports on turbine theory and thermodynamics of vapors. He deplored the lack of exact information on the thermal properties of steam and outlined numerous practical tests, many of which he discussed with Dr. S. A. Moss. In one of these reports Steinmetz reviewed the possibilities of operating elastic-fluid turbines by means of mercury and other vapors of high molecular weight, including tin tetrabromide and perchlor naphthaline, which have molecules more than twice as heavy as a molecule of mercury.

JUNGGREN'S INVENTIONS

The next few years were particularly fertile in detailed inventions. In the five years 1903 to 1907, inclusive, no less than 49 patents were issued to Oscar Junggren, of which at least 14 have proved to be of particular importance in the light of subsequent performance. In 1903 appeared the original idea of the automatic governor which still characterizes all large

General Electric turbines as well as the multivalve, cam-operated control, actuated through relays.

Several important inventions of Mr. Junggren date from 1905. Among these was that for anchoring the intermediate buckets or nozzle sections from the outside. Also a mechanism for longitudinal adjustment of the rotor on account of temperature expansion and the original idea of the hydraulic mechanism with restoring arm which is used on General Electric machines and those of many other manufacturers to the present day.

In 1905 and 1906, patents were issued to Mr. Junggren relating to reheating of the steam during expansion both by means of steam and of combustion gases, but these processes were not used practically in large sizes until many years later. Another 1906 patent shows the first inner casing, so commonly used later.

There were a number of most important inventions in 1907, including the ring-type emergency governor, commonly used today, and a double-flow exhaust. But perhaps the most important of all was a patent depicting an impulse machine with full peripheral admission and incorporating both increasing bucket lengths and increasing pitch diameters from stage to stage. This was the first presentation of the type of machine which was later to prove the most efficient and flexible design to such an extent that at the present day all manufacturers of large efficient machines pattern them in this manner.

SUCCESS OF CURTIS TYPE

The immediate success of the Curtis turbine dating from its first year of commercial offering is a matter of record. Within three years a world-wide market had been established. Machines had been built and shipped to England, Ireland, Germany, France, Japan, South Africa, New Zealand, Siam, Mexico, and Canada, and many purchasers placed successive orders.

In the United States, the Committee for the Investigation of the Steam Turbine reported to the National Electric Light Association at Denver and Colorado Springs in June, 1905, that there were 224 turbines in the "larger sizes" which aggregated 350,000 hp in operation, most of them having been started during the past two years. The report proceeds to give operating information about 57 Curtis turbines totaling 83,500 kw, 34 Parsons machines of 19,800 kw, and 19 De Laval turbines of 1656 kw. There were then ten 5000-kw turbines. The report continues: "All troubles reported were of a minor character—very few and comparatively insignificant," this remark referring to all types of manufacture.

The committee had visited the General Electric Company

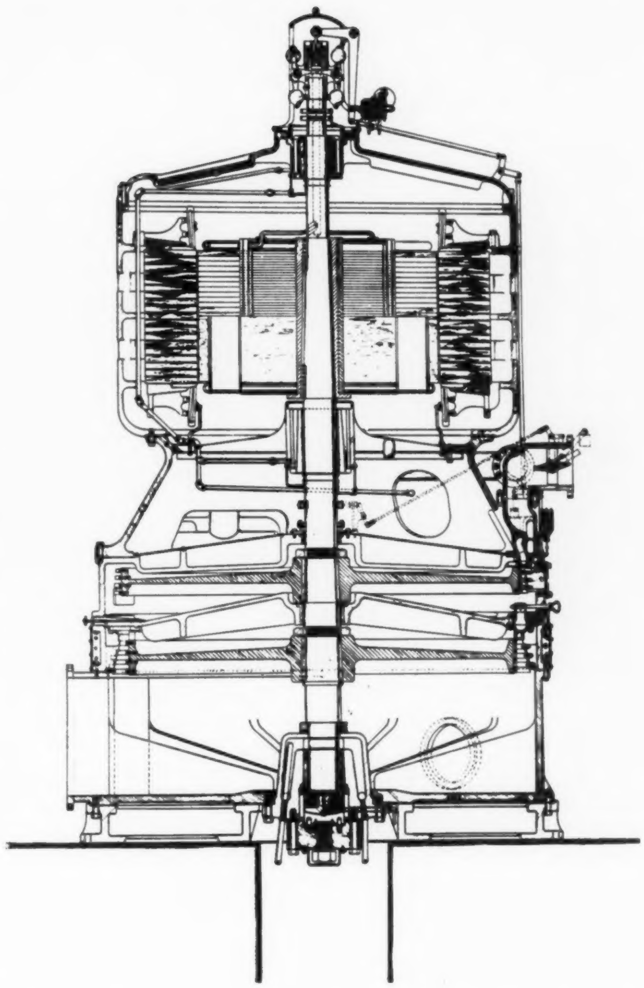
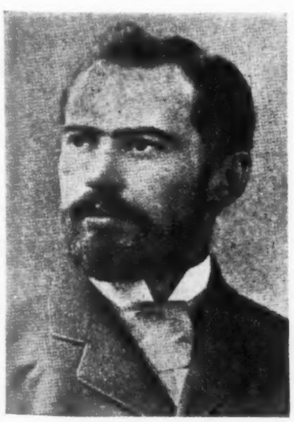
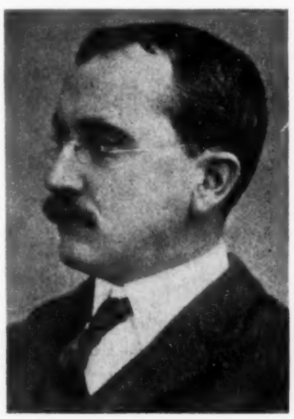


FIG. 4 5000-KW, 500-RPM, TWO-STAGE VERTICAL TURBINE FOR FISK ST. STATION, COMMONWEALTH ELECTRIC COMPANY OF CHICAGO

and admired the valve gear designed by Richard H. Rice of the Lynn Works who had had considerable experience in engine practice. At this time the smaller machines up to 1500 kw were being built in Lynn while the larger ones up to 5000 kw were being built at Schenectady. The committee report continues with particular reference to General Electric turbines:



E. W. RICE, JR., 1890



W. L. R. EMMET, 1904

RICHARD H. RICE, 1920

Step bearings are now being operated with water instead of oil, and the construction has been modified to admit of this change. We have been unable to find a single case where the step bearing has given any serious trouble.

At Schenectady great care has been used in fitting up a complete testing station for steam turbines. The apparatus and the methods have been given most careful attention. The Committee spent some time here and a test was run off to show the methods employed and the apparatus used in the test, and we believe it is the most complete and efficient testing apparatus that has ever been used for testing machinery in a manufacturing works,

and there should be no difficulty in duplicating tests with accurate results.

A test was also made in starting a 1500-kw turbine from rest to find the time necessary to bring the machine up to full speed, synchronize it, and put full load on it. The machine was brought up to speed, synchronized, and loaded with full load in one minute and ten seconds. It was brought up from rest to full speed in a little less than one minute.

It would be hypocritical to evade a frank statement that the Curtis turbine was successful from the start and that it outdistanced all competitors in number and capacity of machines installed. Thus in 1903 the total sales of Parsons turbines from all sources of production throughout the world for the 12 years since 1890 were authoritatively stated as approximating 300,000 hp for land uses and 83,000 hp for marine, in comparison with which the General Electric Company had sold 225,000 hp of Curtis turbines in 15 months. The reasons for this success may not have been clear to everybody at the time and the literature of 30 years ago reflects many discussions of the relative merits of single- and multiple-row wheels, of single-wheel impulse and multistage reaction types. While the Parsons machine and the De Laval turbine were both built earlier than the Curtis turbine, it should be remembered that Curtis, in his patents filed Jan. 16, 1896, and issued Sept. 1, 1896, covered single-row construction. Even to this day a single-row wheel is sometimes referred to as a Rateau wheel; whereas, the earliest claim on the part of Professor Rateau for such construction was filed in 1898 in France. But, although the Curtis patents covered single-row wheels as well as multiple-row wheels, the great success of the early machines was largely due to their incorporation of the multiple-row feature in contrast to the single-row construction on the part of all competitors, whether impulse or reaction.

We now know that single-row wheels are more efficient than multiple-row and there was, therefore, a shadow of merit in such claims for single-wheel construction offered in criticism of the first manufactured Curtis designs. The issue was clouded by the array of actual commercial test data in favor of the Curtis machines as built. The reasons why turbines superseded reciprocating engines are quite obvious, but the reasons why the multirow Curtis wheel was so successful are not so self-evident.

The facts of the case seem to be that the time was not yet ripe for an expensive multistage single-row construction such as characterizes a modern high-efficiency machine. The Curtis multirow wheels proved far more efficient than the single-stage De Laval machine and far cheaper, more compact, and rugged than the many-stage reaction machines of that day. The De Laval machine was decidedly limited in capacity. With only low-grade materials available, the Curtis arrangement was ideally adapted to effect the required energy conversion with a minimum of wheel speed; whereas, neither a single-wheel design nor a reaction design could do this. Some such considerations surely explain the general preference for the Curtis turbine at that time and its great success. Another advantage of the low rotative speed was that the same turbine design could be used with four poles and 750 rpm for 25-cycle frequency or with 10 poles and 720 rpm for 60-cycle frequency. Nearly a million kilowatts of capacity of these vertical machines are still in service throughout the world, some carrying regular loads and others as stand-bys to be relied upon for emergencies and peaks. They still constitute excellent spare capacity for peak-load protection. Their quick-starting ability contributes to their utility for such service, but for continuous service such machines should certainly be replaced with more efficient modern equipment.

In June, 1906, the Committee for the Investigation of the Steam Turbine reported to the National Electric Light Association at its Atlantic City convention with reference to the new General Electric mechanical valve gear used on its smaller-size turbines that "a straw taken from a broom will suffice to move the 100-kw valve gear back and forth." Also bucket speeds had increased from 325–350 ft per sec to 450–460 ft per sec, and further:

> A lengthy discussion was held on the relative advantages of oil or water for step-bearings. It is the consensus of opinion that water is most desirable, although special care should be taken that the water is clean and free from grit of any kind. Oil will give better all-round results, and in future designs the step bearing will be outside the casing for oil bearings.

One standard Curtis turbine was reported by the 1906 Committee as being of the 25-cycle, four-pole type with a capacity of 8000 kw at 750 rpm, and 592 General Electric units aggregating 580,325 kw were reported as shipped or on order, 385 being of 500 kw or larger; a list of machines shipped or installed includes 22 of 5000 kw.

It was at this time that E. E. Gilbert assumed commercial leadership of the General Electric turbine business, a connection that lasted for 26 years. It should be appreciated that any rapidly developing art is completely dependent for progress on commercial acceptance by prospective purchasers. Mr. Gilbert's influence throughout his connection with the business did much to assure such acceptance. A picture of Messrs. E. W. Rice, Gilbert, and Junggren taken at the time of a visit by Sir Charles A. Parsons in 1924 appears at the end of this narrative.

INSTALLATION CREW, 500-KW VERTICAL TURBINE, NEWPORT & FALL RIVER CO., 1903
(Messrs. Bunger, Ambler, Foster, Smallpiece, Chapman, Garvin, Dodge, King, Wilson, Feather.)

FISK STREET STATION

Speaking before the National Electric Light Association in Washington, D. C., in June, 1907, Emmet stated: "During the past year four 9000-kw units have been installed in the Fisk Street Station of the Commonwealth Electric Company of Chicago." Emmet called the Fisk Street Station "the handsomest and most substantial steam plant ever built."

One of these 9000-kw, 750-rpm, 5-stage turbines was tested

by the owners. It carried loads up to 13,900 kw in test and its water rate was 12.9 lb per kwhr at rated load and a gage pressure of 200-lb per sq in., 125 F superheat, and 29 in. vacuum. This represents a heat rate chargeable to the turbine of 15,800 Btu per kwhr.

SUPERHEATED STEAM

With the coming of the steam turbine, steam power plants found it satisfactory to use superheated steam. This step was taken cautiously at first. Accurate information on the properties of steam in the superheated region was scarce. It was at this time that Dodge set up his throttling calorimeter and set out to discover the fundamental thermodynamic properties of the substance he had been squirting through his turbine tests for nearly ten years. In 1908 he published an extensive table of test results on specific-heat ratios for superheated steam, including pressures up to 600 lb per sq in. and temperatures up to 600 F.[2] This early contribution on the part of the General Electric turbine-engineering department to the general stock of information on the properties of steam preceded by 20 years the computation of the 1930 Keenan steam tables in the same office.

THE LYNN TURBINE FACTORY

Within a year of the beginning of manufacture on a large scale in Schenectady, E. W. Rice took steps to transfer the manufacture of turbines in the smaller sizes to the Lynn Works of the General Electric Company. The small-size horizontal turbines were made there as well as vertical-shaft machines up to 1500 kw.

R. H. Rice, like Junggren, a man with successful steam-engine experience, was placed in charge of a separate engineering organization which is still maintained after more than 30 years as an associated but independently responsible organization. This arrangement is not unlike the internally competitive organizations set up and maintained by the large automobile manufacturers, which have been valuable in stimulating progress in the art.

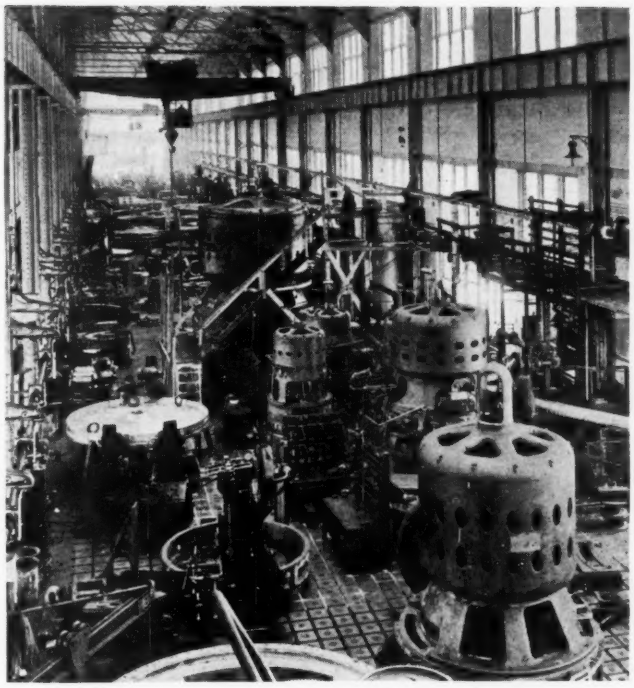
Separate research and development have always been and still are carried on at Lynn but without unnecessary duplication. Many tests on the characteristics of multiple-row wheels were run in the first few years at Lynn and the results of tests run in 1906 and 1907 under the supervision of Dr. S. A. Moss are still applicable.

The "rigid-frame" design of turbine of which well over 2000 were sold in the next 15 years was designed in the years immediately following 1908 under the supervision of Richard H. Rice.

LOW-PRESSURE TURBINES

The present year, 1936, is a year of superposition. Approximately half the turbines being installed are to exhaust into steam mains at 200 to 300 lb per sq in. so as to utilize existing equipment, give it a new lease of life, and protect the older investment from the insidious disease of obsolescence. In view of what is going on now it is interesting to note that there was a campaign in 1908 with respect to low-pressure turbines designed to receive the exhaust steam from existing reciprocating engines. Such combinations secured for the older machines the benefit of a compound arrangement capable of utilizing a high vacuum, and thus enabled the engines to maintain their respectability for another term of years until the mere matter of real estate occupied, in comparison with kilowatts required, forced a more efficient utilization of power-house space.

[2] "A Method of Obtaining Ratios of Specific Heats of Vapors," by A. R. Dodge, Trans. A.S.M.E., vol. 30, 1908, pp. 723–739.



TURBINE FACTORY, SCHENECTADY WORKS, 1904

In May, 1908, John W. Kirkland remarked to the National Electric Light Association at Chicago that two thirds to three fourths of all power was then produced by engines and urged that low-pressure turbines be installed between the engine exhaust and the condenser.

In September of the same year Charles B. Burleigh, addressing the National Association of Cotton Manufacturers at Saratoga Springs, urged the same procedure. Both papers gave diagrams of test results on a Rice-Sargent engine in Schenectady, showing it possible to get 2200 kw with a water rate of 16 lb per kwhr by using a low-pressure turbine as compared to 1200 kw with a water rate of 23 lb per kwhr without it, the engine using such vacuum as it could. According to Mr. Burleigh the same steam from the same boilers would give a maximum capacity of 2500 kw with the low-pressure turbine, or 1480 kw without it. It was at this time that Prof. Ira N. Hollis, of Harvard, advised the Cambridge Electric Light Company that no electric-light company could afford to run an engine alone. In the years following from 1909 to 1918, inclusive, low-pressure and mixed-pressure turbines aggregating 393,800 kw were sold. By 1911 extraction machines were being manufactured for industrial application.

SHROUDS AND PACKINGS

It is now taken as a matter of course that the shrouding for steam-turbine buckets should be cut into separate segments, thus permitting thermal and elastic expansions to occur without overstress and consequent distortion or buckling of the shrouding. This was the basis of an important patent issued to W. L. R. Emmet in 1909, eight years after its invention. This patent was upheld by the courts, and has been used in every commercial turbine manufactured by the General Electric Company and is used by all makers of impulse turbines at the present time.

Another important invention was Junggren's patent in 1910 for a shaft packing which could move away from the shaft on contact but could not return closer than a definite circular stop would permit. This design is universally used on General

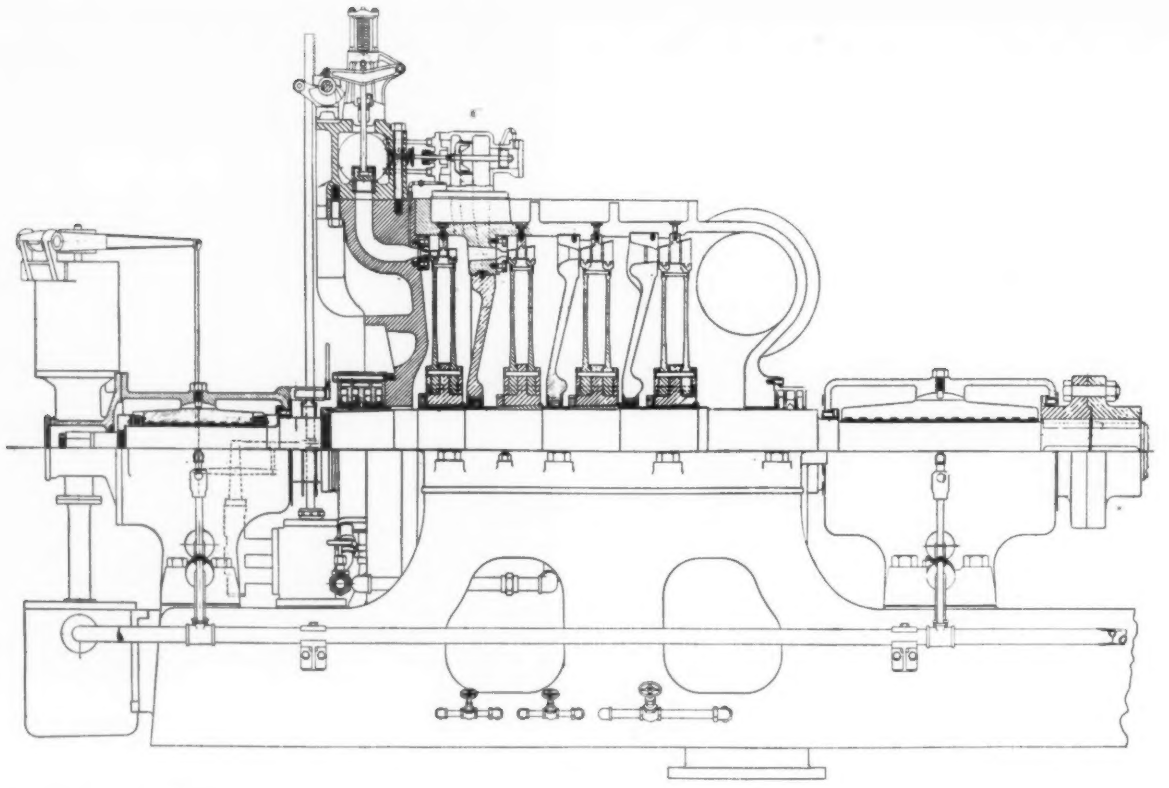


FIG. 5 1500-KW, 1800-RPM, FOUR-STAGE HORIZONTAL TURBINE FOR PUBLIC SERVICE ELECTRIC COMPANY, CRANFORD, N. J., 1908

Electric turbines at the present day and by many other manufacturers throughout the world.

HORIZONTAL SHAFTS

In 1908, a 1500-kw, 1800-rpm, four-stage turbine with a horizontal shaft was completed for the Public Service Electric Company at Cranford, N. J. Fig. 5. Throughout the preceding five years, during which time all machines of 500 kw and up were built with vertical shafts, there had been built a large number of small units for direct-current electric generation ranging in size from 15 to 300 kw and running at speeds from 4000 rpm in the smaller units to 1500 rpm in the larger. Charles B. Burleigh told the National Association of Cotton Manufacturers in New York in 1906 that the number of such machines sold exceeded the number sold by any other manufacturer of horizontal turbines in this country.

Vertical-shaft turbines of 14,000 kw capacity were in operation at this time, but the limit for machines of that type was already in sight. Vertical turbines of 20,000 kw were built and shipped in 1911, 1912, and 1913, but no more were built thereafter.

In 1909, a 4000-kw, 1200-rpm, five-stage horizontal machine was built for the North Shore Electric Company at Blue Island, Ill., later a part of the Commonwealth Edison Company of Chicago. The next year a 5000-kw, 1500-rpm, seven-stage horizontal machine was shipped to Worcester, and in 1911 a similar machine rated 7500 kw to Blue Island.

In 1911, tests were run in the factory on a 2000-kw horizontal turbine with different arrangements of two-row and single-row wheels. It was run with four two-row wheels and later it was run with the last two replaced by seven single-row wheels in which more than half the energy conversion took place. The single-row wheels plainly demonstrated their higher efficiency.

It was at this time that the three famous Navy colliers were built, the turbine-electric *Jupiter*, the turbine-gear-driven *Neptune*, and the engine-driven *Cyclops*. The first turbine built for the *Jupiter* had six two-row wheels and test results showed somewhat better than guaranteed performance. However, in view of the results on the factory test turbine, a new unit was built with nine stages, the first being two-row and the other eight single-row wheels, and this machine was a good 10 per cent more economical than the first. The fascinating narrative of the superior performance of the *Jupiter* as the first demonstration of turbine-electric drive and the fulfillment of E. W. Rice's vision of a decade earlier, is told by Emmet in chapter 9 of his autobiography.[1]

Out of these experiences with the test turbines and their application to the *Jupiter* came consequences of long range. On the one hand came turbine-electric drive for large naval vessels such as the airplane carriers, *Saratoga* and *Lexington* (the *Jupiter*, afterward was converted into the *Langley* which is still in service after more than 20 years) and for large passenger boats such as the *Normandie*, equipped by an associated French company with the General Electric Company cooperating in a consulting capacity. On the other hand the necessity for future expansion in the direction of single-row wheels requiring more stages and longer shafts in proportion to wheel diameter gave one good reason why shafts would henceforth have to be horizontal.

In the next couple of years there was developed a fairly definite type of design for horizontal turbines having 7 to 12 stages, the first having two rows of buckets, with nozzle governing, and the others being single-row wheels with little change in pitch diameter. Fig. 6 is typical of these machines. The decision to exploit the horizontal-shaft type was largely made under the inspiration of Oscar Junggren.

In 1912 the 10,000-kw, 1500-rpm, 12-stage turbine was de-

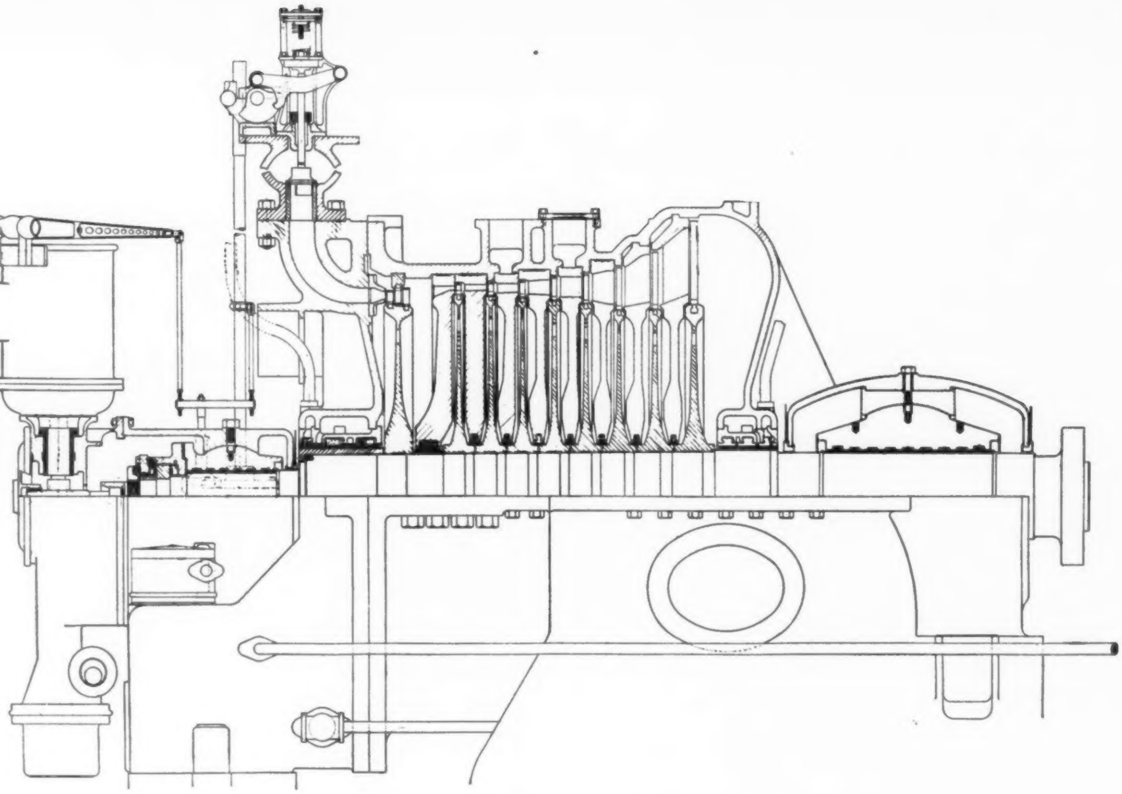


FIG. 6 7500-KW, 1800-RPM, NINE-STAGE TURBINE

signed for the Lehigh Coal and Navigation Company. This turbine had one two-row and 11 single-row wheels. Its high efficiency on test went far to establish the success of the horizontal type.

The same year Junggren went to Europe and derived much inspiration from seeing how European manufacturers were meeting their design problems. Although in certain minor respects General Electric designs at the time reflect his observations abroad, they remain essentially American in conception.

It seems to be a characteristic of the General Electric turbine development throughout its history that in none of the more essential details has it ever found it necessary to rely on European assistance and talent. The single exception to this conclusion is its short-lived effort to exploit the Ljungström turbine in this country, which proved abortive and was abandoned.

In June, 1912, the General Electric Company told the Prime Movers Committee of the National Electric Light Association in Seattle that it was "prepared to furnish Curtis turbines of the horizontal-shaft type of any capacity desired." This promise marks one of the milestones in the development of the Curtis turbine. While the vertical-shaft machines of the first decade had formed the basis of a great expansion in the electric-power industry they were not adapted to go on to still larger sizes. The change to horizontal shaft facilitated the use of more adequate condensing equipment, enabled the use of much larger volumetric flows to exhaust without excessive leaving-velocity losses, and permitted direct coupling to generators which could also grow in capacity in their own separate bearings.

The Transactions of The American Society of Mechanical Engineers have from time to time included papers on the history or current status of the steam-turbine art. In giving such records a longer scope at a later date, it is of interest to review what has been said before.

In 1912, A. G. Christie[3] wrote:

> Many European engineers hold the opinion that where high economy is to be obtained, the impulse turbine of the Rateau or Zoelly type is superior to the Curtis, though its manufacturing costs are higher. The Curtis-Rateau construction has all the commendable features of impulse turbines and has proved very economical.

Professor Christie's terminology is unfortunate in restricting his use of the Curtis designation to the multiple-row wheels which proved to be the most successful construction of their time. While they thus characterized the early Curtis machines, the Curtis patents comprehended the use of single-row wheels so that it is entirely unnecessary to use a hyphen to describe the later designs of Curtis turbines when the time was ripe for more expensive multistage turbines with single-row wheels.

Professor Christie goes on with prophetic insight:[4]

> The writer offers as his opinion that the combined types such as the Curtis-Parsons, the Curtis-Rateau, and also the Curtis-Rateau-Parsons, previously described, will very soon supersede the simple types. It is probable that the Curtis turbine will eventually be built only in horizontal units and will gradually be modified to a Rateau or even a drum impulse construction in the low-pressure sections. The freedom from close adjustment in impulse turbines and the recent improvements in blading materials will greatly increase the use of this type, although Curtis-Parsons turbines are said to be cheaper to manufacture. In actual operation, it is an open question among engineers whether the reaction turbine has a higher commercial efficiency than the impulse type, and hence buyers usually consider first cost and personal preference only.

THE SECOND DECADE

By this time the Curtis turbine was ten years old as a prime mover. Between 2,000,000 and 3,000,000 kw were in opera-

[3] "The Present State of Development of Large Steam Turbines," by A. G. Christie, Trans. A.S.M.E., vol. 34, 1912, p. 476.

[4] Ibid., p. 483.

tion throughout the United States. The period of rapid expansion was at hand. The close approach to limiting sizes and the problems incident thereto were still in the future. Whether the problems incident to the beginning of an art are greater than those associated with pushing it to the limit, is a matter for argument. Perhaps inventive genius is most important at the start while sound engineering technique is more important later on.

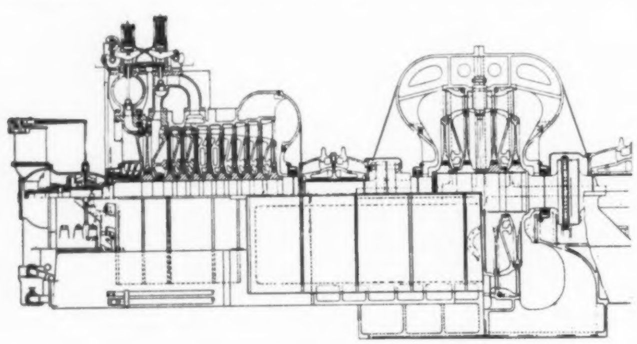


FIG. 7 30,000-KW, 1500-RPM, 12-STAGE, TANDEM-COMPOUND, DOUBLE-FLOW TURBINE FOR NEW YORK EDISON CO., 1914

In October, 1913, the first 20,000-kw horizontal machine was shipped to Chicago. This machine had nine stages, operated at 1200 rpm, and was placed in commercial service the following February.

On Nov. 21, 1913, the New York Edison Company ordered a 30,000-kw machine. It was manufactured and shipped Oct. 1, 1914, steamed Nov. 3, and placed in commercial service Nov. 9, 1914, less than a year from receipt of the order. This was at the time the largest single generating unit ever installed. The turbine had 12 stages, the first being a two-row wheel. The second to tenth stages, inclusive, were single-row wheels contained in the same casing with the first stage. The last two stages were arranged for double flow with two wheels each in a separate double-ended casing. Fig. 7.

In 1916, the first two 30,000-kw, 1800-rpm, 17-stage turbines were being manufactured for the Wheeling Electric Company. A similar 20-stage design rated 35,000 kw at 1500 rpm had been laid out for 25-cycle power. The Wheeling machines were shipped in 1917 and constituted the first large-scale embodiment of the conical-flow type eventually approached in one way or another by every manufacturer of large efficient turbines. This design is shown in Fig. 8. Its importance can hardly be overestimated. The change was so radical in comparison with types which had previously been manufactured that the plans were laid before E. W. Rice, then president of the General Electric Company.

A conference was held and it was decided to build a machine of this new type and get experience with it before proceeding with the general sale. This resolution was short-lived, and, in view of what happened later on, it should be noted that such was the pressure of business at this time that more than 40 machines totaling more than a million kilowatts of this or of similar layout for other speeds and sizes were sold before the first was placed in continuous commercial service in 1917. Speeds were 1200, 1500, and 1800 rpm; sizes from 20,000 to 45,000 kw, and numbers of stages from 17 to 23. From the 1800-

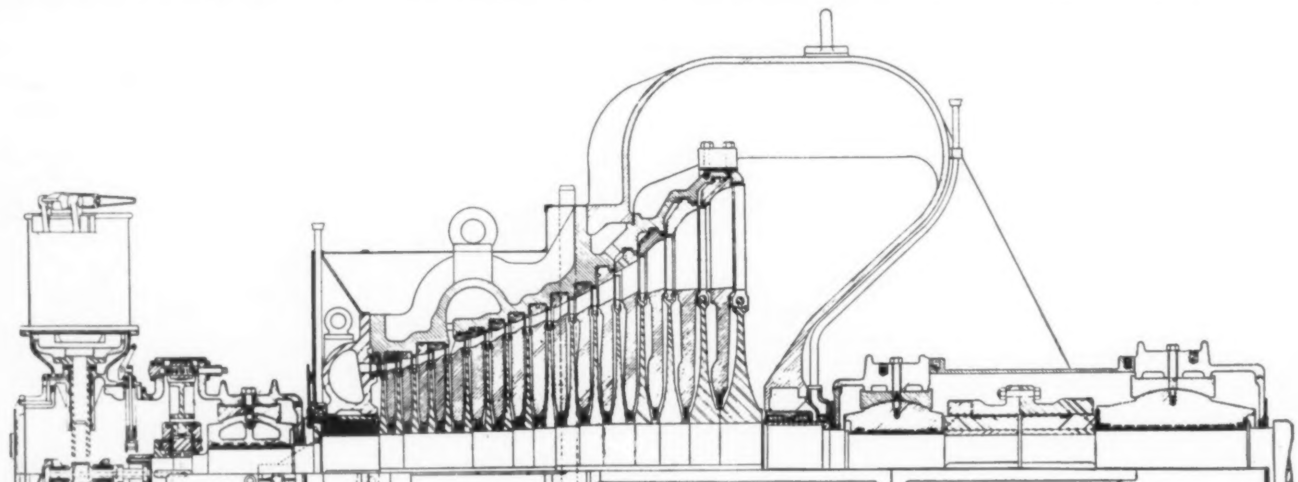


FIG. 8 30,000-KW, 1800-RPM, 17-STAGE TURBINE FOR WHEELING ELECTRIC CO., 1917

rpm, 17-stage layout alone, nearly 50 machines were built before the shell patterns were altered to permit the use of higher pressure up to 400 lb per sq in. gage, and then about as many more were built in more recent times for the higher pressure level.

In 1917, the first 45,000-kw turbine was installed at Detroit. In May of that year the General Electric Company reported to the Prime Movers Committee of the National Electric Light Association at New York that its orders for the past year had been equal to three times those received in any previous year while the average size of machine ordered was 50 per cent larger.

The United States was at last in the war, and aside from the strenuous effort to produce more kilowatts and still more kilowatts, there were two noteworthy developments stimulated directly by the war-time activity, both in the field of ship propulsion.

MARINE PROPULSION

Propulsion plants for approximately 350 cargo boats were manufactured during the war period for the Emergency Fleet Corporation and others. These sets were rated 3000 hp; with a maximum speed of 3500 rpm. There were five stages for ahead and two for astern operation, and the propeller shaft was driven through double-reduction gears. Fig. 9.

At the same time a high-power, multistage compound design was manufactured in considerable numbers for destroyers of the U. S. Navy. These also were gear-driven ships. The turbine plant was in two cylinders, the high-pressure or "cruising turbine" being used under normal conditions and bypassed for maximum power. E. D. Dickinson (since 1922 in charge of turbine design at the Lynn Works of the General Electric Company) was largely responsible for the details of these designs.

Twelve 6000-hp double-reduction-gear propulsion sets were also built for Army and Navy transports.

THE LJUNGSTRÖM TURBINE

This narrative would not be complete without some reference to the five-year effort of the General Electric Company to exploit the Ljungström type of machine. It has been so well described elsewhere that it is not necessary to go into the radial-flow design here. Its highest pitch of development has been reached in Sweden and England where many very successful and efficient units in the smaller sizes are in operation. The design is extremely ingenious and it is the only truly pure reaction turbine, the steam moving through it with little absolute velocity. The so-called reaction turbines of the axial-flow type all develop about as much energy in their stationary nozzles as in their rotating blades, and the steam attains absolute velocities approaching the peripheral speed of the blades.

It is a fact that textbook writers had expressed a preference for reaction blading and the lower absolute velocities associated with it. Although this was in a sense a siren song since overall efficiency is what really matters, very efficient Ljungström turbines were operating in Europe and under European factory conditions were manufactured at low cost. The designers induced the General Electric Company in 1916 to take a license for the manufacture of the Ljungström machine. J. H. Doran of the turbine-engineering department, C. Steenstrup of the factory organization, and A. F. Macdonald of the patent department forthwith went to Sweden, during war conditions, to acquire manufacturing and patent information. Three machines were built rated 1000, 15,000, and 30,000 kw, the last two larger than any previously built abroad.

While these were nearing completion the author, Ernest L. Robinson, went to Sweden in 1920, spent the winter at the design office near Stockholm, and visited every accessible installation in England, Sweden, and France. There was no denying that this type of machine was highly successful in sizes up to 5000 kw and very efficient. It was not clear that it was more efficient than multistage impulse machines.

Under the direction of Richard H. Rice at its Lynn Works the General Electric Company had built and tested several multistage turbines of sizes up to and including a 3000-kw, 3600-rpm, 40-stage turbine which gave, in test, an efficiency closely the same as that of the best Ljungström machines. (This was some years before a European manufacturer claimed as a discovery the high efficiency associated with an extreme number of stages and even went so far as to seek patent protection in that direction.)

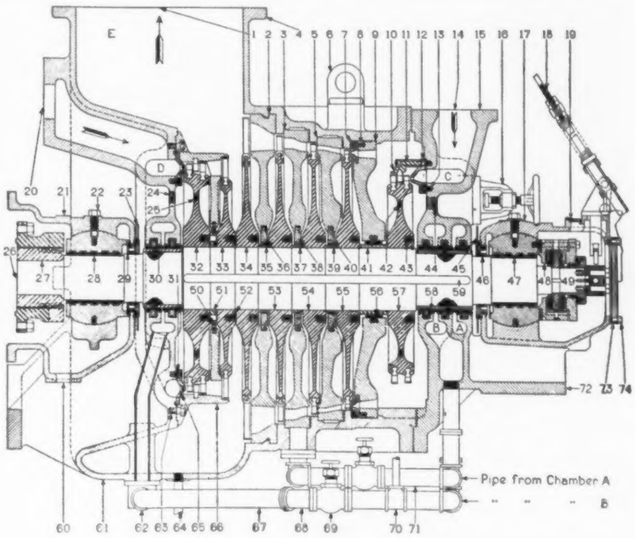


FIG. 9 3000-HP 5/2-STAGE GEARED MARINE TURBINE

The Ljungström machine had proved expensive to manufacture under American factory conditions, and with both relative cost and relative efficiency becoming more and more uncertain, it appeared of doubtful wisdom for the General Electric Company to divide its energy between two distinctly different forms of construction.

The last straw was the bursting in test of one of the exhaust wheels on the 15,000-kw machine, Mr. Doran escaping sudden death by a few inches only. Although oscillograph records disclosed the cause as violent nodal vibration which was already beginning to be understood, this accident was severe enough to ring down the curtain on this attempt to graft foreign talent on an American rootstock.

WHEEL VIBRATION

In May, 1919, the Prime Movers Committee reported to the National Electric Light Association at Atlantic City:

> The most serious situation that has developed in the type and sizes of units under consideration, however, has been the number of quite recent turbine-wheel failures. In several instances these accidents have resulted in the complete wrecking of the units concerned. Such accidents, which are without parallel in the history of steam-turbine development, can hardly be considered as bearing directly on the question of performance of large-sized units, but rather as a factor to be considered in the improvement of design and construction of a specific type of unit.
>
> The situation is now a critical one, and, while any definite statement at this time would be premature, the Committee wishes to indicate the necessity for early action, both in safeguarding against further possible failures of machines now in operation, and in reaching definite solutions

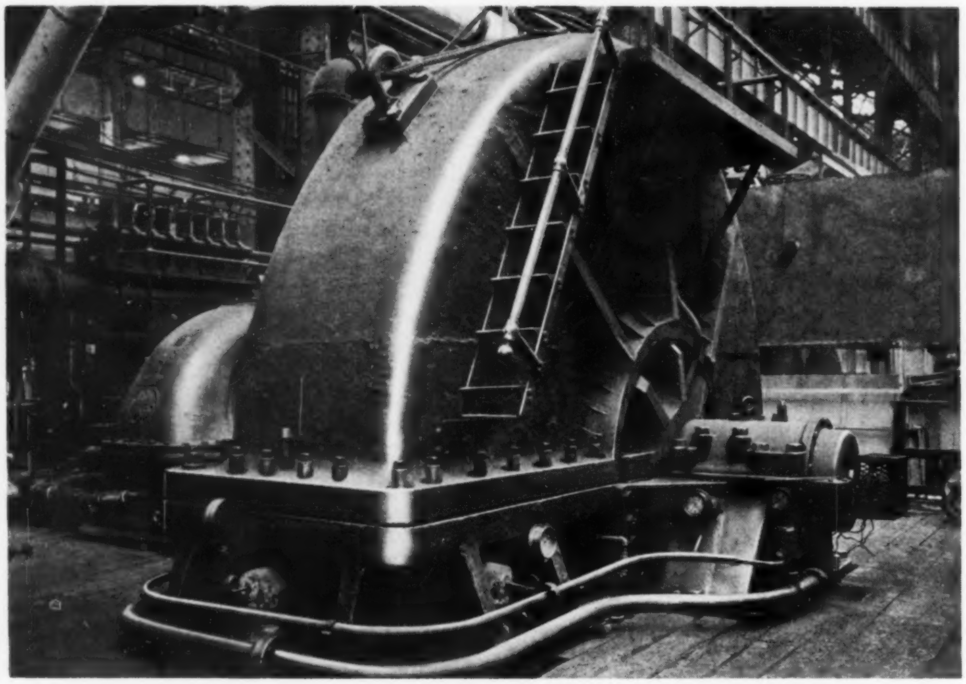


FIG. 10 MACHINE FOR DETERMINING NATURAL FREQUENCIES OF TURBINE WHEEL AND BUCKET VIBRATION

of those problems which involve important features of design and construction.

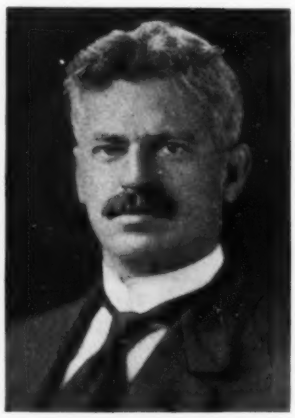
The situation referred to by the committee constitutes perhaps the most serious engineering hazard encountered and overcome in the entire history of turbine development. The explosive energy in a ton or two of metal traveling at projectile speed is capable of doing great damage.

The research investigations, the discovery and analysis of the phenomena of wheel vibration, and the carrying out of the precautionary measures for safeguarding operating turbines covered a period of nearly five years from 1919 to 1924. The technical circumstances have been made a matter of record in the classic Campbell paper,[6] the larger part of which was composed by A. L. Kimball, Jr., and the author, since Campbell's genius was more mechanical than literary. Without repeating the technical details, the general circumstances may be recounted briefly.

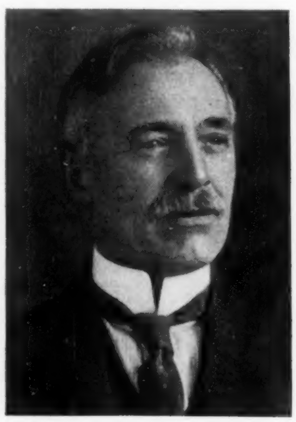
Throughout the early years, high-speed wheels had been designed with reference to the elastic-stress distribution produced by centrifugal force. When such wheels carried more than one row of buckets, there was a wide rim which lent transverse stiffness to the wheel, but as single-row wheels came to be more commonly used, the stiffening effect of the wide rim disappeared and the possibility of transverse resonant vibration became greater. As refinement of design progressed, it was only natural to equalize the stress distribution by removing weight from the outer portions of the wheel web so as to accomplish the twofold purpose of reducing the maximum stress which occurred near the bore of the wheel and increasing the efficiency of material utilization in the outer part of the wheel web by thinning that region. This whole process tended to give a uniformly stressed material, but at the same time transverse stiffness was greatly reduced. Even so, the number of cases in which a resonant condition was incurred was rather small. But when the stiffness was so far reduced as actually to make possible the condition of forced vibration under ordinary conditions of operation, then the matter became serious.

All of this is what was found out afterward. It is necessary to bear in mind now that comparatively little was known in those days about the behavior of materials under what is now referred to as the fatigue of repeated bending. Furthermore, it required what was to many an unfamiliar point of view to realize that the very high centrifugal forces were, like an acrobat's landing net, quite as elastic with reference to transverse vibration as the steel out of which the wheels were made. These forces in the plane of the wheel, so far from preventing transverse vibration, merely changed its frequency.

The whole situation, when it arose, changed very quickly from one or two isolated cases to a characteristic of certain wheels in the new designs. Something had to be done about it vigorously and promptly, and although the presence of vibration was suspected, no one knew just what to do about it. It was at this time that C. E. Eveleth, newly returned from chasing submarines with ingenious listening devices, was asked to take hold of this situation.



C. E. EVELETH, 1913



OSCAR JUNGGREN, 1924

W. J. DELLES, 1930

[6] "The Protection of Steam Turbine Wheels From Axial Vibration," by W. Campbell, Trans. A.S.M.E., vol. 46, 1924, pp. 31–160.

In view of the rapid expansion of the business under the stimulus of war industry, it was an important decision whether the General Electric Company should continue and expand a type of business which looked as if it might turn out to be unprofitable. Although the turbine business was nearly 20 years old at the time, the capacity of machines shipped since that time, including the depression years, has been more than double all those in operation at the time these difficulties began. Eveleth's advice to go ahead has been amply justified. Beginning in 1919, he got together an organization of new talent, drawing upon the research laboratory and other departments, as well as engaging new men from schools or outside the company.[6] For the detailed accomplishments which resulted, the reader should consult the Campbell paper.[5] A large amount of cooperative research on the strength of steels to resist the fatigue of repeated bending stress was sponsored at the University of Illinois under the direction of Prof. H. F. Moore. A great deal of analytical work resulted in refinement of design detail in the matter of reducing stress concentrations and improving the manufacturing finishes to increase fatigue strength. A. L. Kimball spent nearly a year in London with Prof. E. G. Coker and brought back complete apparatus for photoelastic-stress analysis, the first to be set up and placed in use in this country.

Within a year or two there was a general appreciation of what was going on in turbines, but there were so many different varieties of vibration possible that it was difficult to arrive at any decision as to which types were most serious and as to what should be done about it. In this matter Campbell's genius became effective. The wheel-testing machines and the collection of mechanical and electrical equipment assembled to study wheels under actual conditions of vibration were largely based on his ideas. The larger of these two machines is a necessary part of General Electric factory equipment at the present time. See Fig. 10.

Campbell's thesis was that the destructive cases of wheel failure occurred when a backward traveling wave in the wheel proceeded at exactly the same speed at which the wheel was moving forward, so that the wave remained stationary in space and was easily susceptible to stimulus by any small fixed pressure spot. If such conditions were avoided by suitable margins from resonance, dangerous conditions would be avoided. The Campbell patents were based upon this conclusion and the program for the survey of all operating turbines and for suitable repair was laid out along these lines and occupied the next few years.

In 1924 occurred Campbell's untimely death. He was taken sick while inspecting a turbine in Chicago and hurried home, but an operation for appendicitis proved to be too late. The extension of his theories to cover the case of tangential vibration of buckets in or close to the plane of the wheel had been pretty well formulated and this work was carried on by W. C. Heckman, who presented a paper to The American Society of Mechanical Engineers on that subject.[7]

PERFECTION OF BALANCE

An important by-product of Campbell's activity was the development of handy, portable, vibration-amplitude measuring devices of the seismographic type. These gadgets took the uncertainty out of the magnitude of casing and foundation vibration. This type of vibration should not be confused with wheel vibration which is balanced internally and is imperceptible from the outside.

While a turbine rotor, made up of a series of wheels strung along a shaft, should be in perfect dynamic balance if each individual wheel is in perfect static balance, it is entirely possible even with well-balanced individual wheels for cumulative effects to give a net running unbalance big enough to cause annoying vibration in any resonant parts of the bearing or foundation structure.

The growing sizes of rotating parts and the ability to set definite magnitudes to the structural vibration caused by any imperfections of balance resulted in steps being taken to assure more perfect balance in rotors before they left the factory.

Akimoff had been perfecting his balancing equipment for small rotors, and in 1920 an agreement was reached with him whereby the General Electric Company could construct balancing apparatus of his design suitable for large rotors. More recently the equipment developed by E. L. Thearle of the General Electric Research Laboratory has been widely used for perfection of balance, especially in the field.

THE IMPROVEMENT OF INTERNAL EFFICIENCY

When Eveleth arrived at the conclusion that there was a great future in the turbine business, he also became convinced of the soundness of extensive research with reference to turbine efficiency. When a turbine eats its purchase price in coal at least once a year if not twice, it is easy to arrive at the conclusion that you could hardly accept one as a gift if it should fall down ten per cent in water rate. Conversely, as Junggren always said, purchasers would be eager to pay handsomely for any improvements which would reduce their coal bills.

Consequently, at the same time that an organization was built up to deal with the vibration situation, an attack was instituted on the determination of the many detailed losses throughout the machine. Designs being manufactured had outgrown the coefficients established a decade earlier, and no comprehensive program of analytic tests had been undertaken in the meantime. The emphasis of effort had all been on the production of capacity. While the machines always carried load, in some cases water rates were excessive. All the various losses were analyzed and segregated approximately as to magnitude, and a program of investigation instituted to measure and try to reduce each. Thus there were packing-leakage and rotation-loss tests, nozzle and bucket tests, exhaust-hood and valve-loss tests.

Three activities in particular stand out as of distinct significance, namely, the reaction nozzle-testing machine, the so-called "air test," and the 3000-hp test turbine. Of these various tests, the air test is still in active use as a regular tool of design. The several machines and the test programs were largely the result of ideas which originated with G. B. Warren. J. H. Keenan was in charge of the nozzle-testing machine, H. L. Wirt of the air test, and H. D. Kelsey of the 3000-hp test turbine.

The nozzle reaction testing machine was designed in 1920 and was in constant use for six years. Much was learned from this machine about the behavior of high-speed steam jets and many different types of nozzles were tested. A description may be found in the paper by G. B. Warren and J. H. Keenan entitled, "A Machine For Testing Steam Turbine Nozzles by the Reaction Method."[8]

This paper simply described the machine and gave sample tests. Any presentation of the results of the work done on this machine in such detail as was given by the British committee with reference to a few similar tests would fill volumes. How-

[6] It was at this time that the author joined the General Electric Company.

[7] "Tangential Vibration of Steam Turbine Buckets," by Wilfred Campbell and W. C. Heckman, Trans. A.S.M.E., vol. 47, 1925, pp. 643–671.

[8] Trans. A.S.M.E., vol. 48, 1926, pp. 33–64.

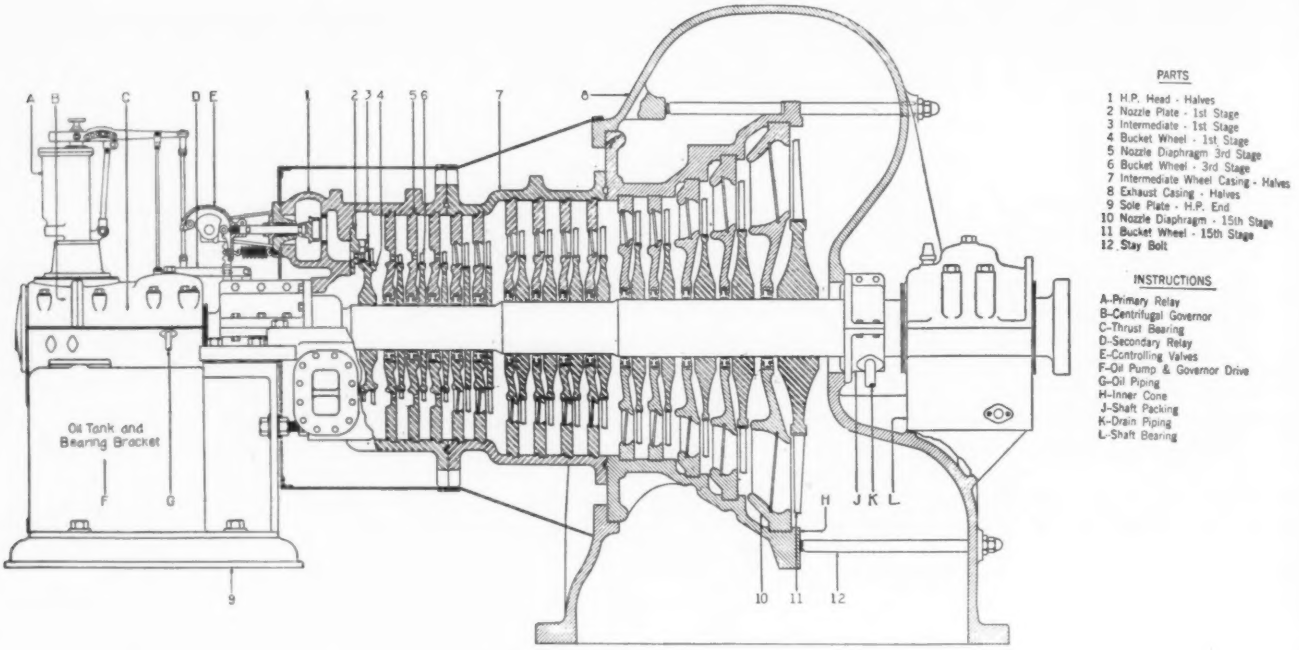


FIG. 11 5000–7500-KW, 3600-RPM CONDENSING STEAM TURBINE

ever, as a tool readily adaptable to design use, this machine was not so practical as the air test. It was much more expensive to operate, the sample nozzles cost more than the air-test models, and the answer obtained was one of overall performance, whereas the air test was able to survey every corner of the high-velocity jet.

The air test, now housed in a spacious laboratory and equipped with autographic mechanism, was first started in 1920 in the power house where compressed air was available in quantity, but because of its noise, it was moved in 1921 to a "shack" just outside. This equipment was described by H. Loring Wirt in a paper entitled, "An Experimental Investigation of Nozzle Efficiency."[9]

All the interior passages of a turbine—nozzles, buckets, crossover pipes, valves, and exhaust hoods—were examined with impact-tube traverses, and in 1920 W. E. Blowney put wet paint on the inside of the models so the air could record its own streamlines, while Wirt preserved them permanently by making plaster casts of the flow passages.

This was ten years before "streamlining" became a by-word of American advertisements. As early as 1910, Dr. S. A. Moss had similarly used whitewash to study air flow within a compressor. Continually perfected and enlarged, the air test is one of the most effective tools of design in use today.

The 3000-hp test turbine was operated from 1920 to 1926. In this were run overall tests on single wheels, both single-row and two-row, as well as tests involving up to eight stages as a complete turbine. Power measurement was accomplished first with a water brake, but later and more accurately with an electric generator connected to a water rheostat. While turbines of extremely high efficiency had been built in the years preceding these tests, there had been notable instances of failure to meet guaranteed commitments which were rather unexplainable at the time. The tests on the 3000-hp turbine showed a range of internal efficiency in excess of 10 per cent as between some designs current at the time and designs embodying in combination all the good elements known to the art. Buckets were tested with various edge thicknesses, overlaps, and area ratios, and corresponding tests were made on nozzles including finish and throat length. New and more efficient nozzle shapes were worked out. Packings were studied and thrusts measured. Special tests were run on two-row wheel combinations, and a complete series of single-row characteristic efficiency curves was determined which, with proper analysis and correction, has been used as the basis of much of the design since.

The whole program gave assurance that improvements indicated by the air test could be realized in an actual turbine and the final result was the complete elimination of all inability to attain performance commitments. Since 1926, 30 performance tests, sponsored jointly by owner and manufacturer, have been conducted on General Electric turbines in sizes ranging from 10,000 to 208,000 kw, and in none of these tests did performance fail to equal or surpass commitments.

Eveleth was in the turbine organization of the General Electric Company less than four years, but he left as a heritage an organization of developmental experts concentrating on the perfection of the structural soundness and mechanical perfection of the machine as well as the intrinsic efficiency of every detailed part. Concentrating energy on this work in 1920 and 1921 in what was then called a period of depression, this effort has never since been allowed to lag. While there have been additions of younger members to the organization, the thread of personnel continuity has never been broken. Eveleth was succeeded in the administration of turbine engineering by W. J. Delles, who was without technical training, but gifted in organizing and dealing with men. It is particularly significant to note in retrospect that in the years which followed, Junggren, although carrying a fractionally smaller share of the responsibilities, contributed his greatest achievements of design to which the majority of big machines in the central stations of the country bear witness.

THE PROPERTIES OF HIGH-PRESSURE STEAM

After Mr. Junggren's death last year, in clearing out his desk, there was found a clipping from the technical press in 1916, setting forth the advantages of high steam pressures for

[9] Trans. A.S.M.E., vol. 46, 1924, pp. 981–1003.

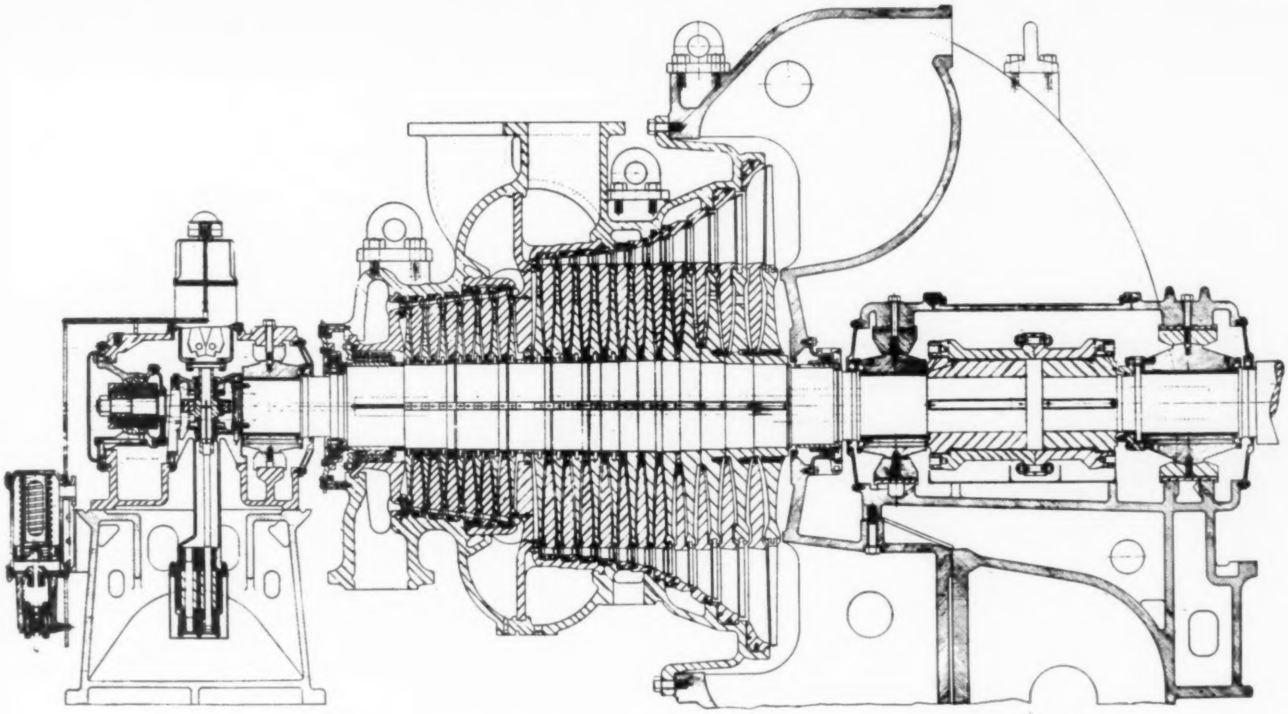


FIG. 12 40,000-KW, 1800-RPM, 19-STAGE RESUPERHEATING TURBINE FOR PHILO STATION, OHIO POWER COMPANY

central-station operation. This subject had attracted Junggren's interest as early as 20 years ago. In 1920 Junggren came to the author for estimates as to the thermodynamic advantage of operating turbines at a pressure of 1000 lb per sq in. as compared with the 200 lb per sq in. then current. Although the Marks and Davis steam table extended to 600 lb pressure, it was based upon experiments conducted at pressures below 200 lb per sq in. The author laid this situation before Professor Davis who expressed his regret that no better data were available and suggested that perhaps Geo. A. Orrok might be induced to organize a cooperative effort to secure the necessary information. There was a meeting in Cambridge in 1921, which resulted in the formation of the A.S.M.E. Special Research Committee on the Thermal Properties of Steam. The succeeding cooperative work between Harvard University, Massachusetts Institute of Technology, and the Bureau of Standards under the sponsorship of this A.S.M.E. committee is a matter of record. The Harvard apparatus, good for 600 lb pressure, was set up and ready. By the latter part of 1923, Joule-Thomson coefficients were available up to 600 lb pressure, and there was some definite information for revision of the properties of steam at such pressures. The 35,000-kw reheat machines for Philo and the 60,000-kw cross-compound reheat machine for Crawford Avenue were being designed for operation at 600 lb per sq in. gage pressure, and it was necessary to have the latest available information on the properties of steam suitably analyzed. After careful consideration, J. H. Keenan, who had been devoting most of his time to the analysis of tests in the nozzle-testing machine, was invited to undertake the analysis of the new information and prepare revised charts good enough to form a working basis for turbines being manufactured. The first of these charts was presented to the A.S.M.E. committee on October 20, 1925, and printed in Mechanical Engineering in February, 1926, entitled, "Progress Report on the Development of Steam Charts and Tables from Harvard Throttling Experiments," by J. H. Keenan. This chart extended to 750 lb per sq in. pressure and 800 F temperature. Because of the uncertainty of further extrapolation, an auxiliary chart accompanied the paper extending to 1200 lb per sq in.

Until this information began to be available much use had been made of Goodenough's steam table. His 1916 chart extended to 800 lb per sq in. pressure and 600 F temperature and his formulations facilitated extrapolation. Although it was not known at that time, the recent findings of the International Steam Table Conference have shown that Goodenough's 1916 table was really very good even at the higher pressures. Engaged as a consultant by the General Electric Company, Prof. G. A. Goodenough spent the summers of 1924 to 1928 in its turbine-engineering department.

By 1928, the measurements of specific volume at the Massachusetts Institute of Technology had proceeded up to pressures beyond the critical and had released a large amount of further information, going to show that considerable revision was necessary in the small auxiliary chart drawn by extrapolation two years previously. Keenan this time prepared a complete table of the properties of steam and a new Mollier chart extending to the critical point. This was presented to the committee at the annual meeting, December, 1928, and published in Mechanical Engineering for February, 1929. It constituted the Keenan steam tables as published under the sponsorship of The American Society of Mechanical Engineers in 1930.

DEVELOPMENT AT LYNN WORKS

Until close to the end of the war, the turbine-engineering department at the Lynn Works of the General Electric Company had been functioning under the leadership of Richard H. Rice. However, early in 1920, Mr. Rice assumed complete management of the River Works at Lynn and for the next two years turbine design was in charge of Dr. L. C. Loewenstein, the translator of Stodola. He was succeeded in 1922 by E. D. Dickinson (mentioned before in connection with marine pro-

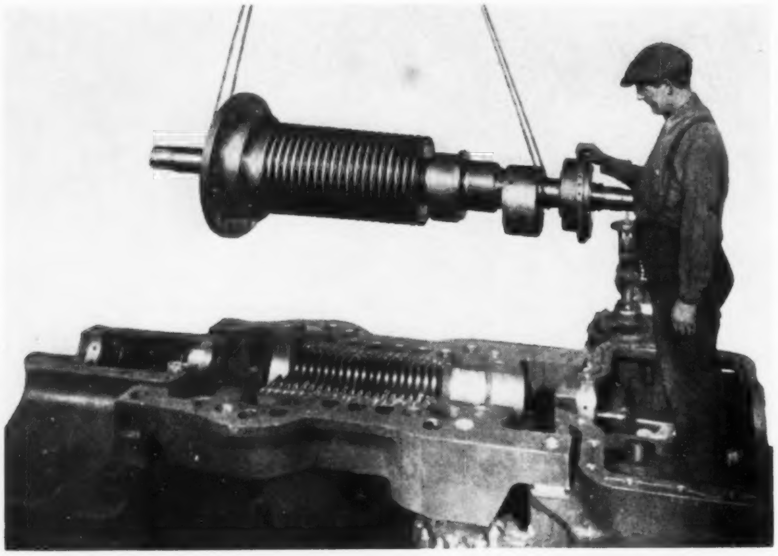


FIG. 13 3000-KW, 3600-RPM, 20-STAGE TURBINE FOR 1200 LB PER SQ IN. GAGE, 700 F, 360 LB PER SQ IN. GAGE BACK PRESSURE FOR EDISON ELECTRIC ILLUMINATING CO. OF BOSTON

pulsion design at Schenectady). Mr. Dickinson had also had long previous experience at Schenectady in the design of turbines for industrial application, mixed-pressure and extraction machines for industrial uses having become common as early as 1912. Under Dickinson's direction the Lynn engineering department proceeded with the development of a standardized design capable of assembly by the factory to suit a wide range of steam conditions as well as various fields of application up to 7500 kw. With a standard head end and several standard sizes of exhaust, the intermediate shell could be arranged for various extraction requirements. See Fig. 11. There was also a complete line of smaller-capacity machines from 5 hp up for mechanical-drive purposes.

MOSS SUPERCHARGER

Although it is not a steam turbine, some mention should be made of the supercharger for airplane engines designed and manufactured under the direction of Dr. S. A. Moss at the Lynn works of the General Electric Company. This is, perhaps, the most successful application of a gas turbine which has so far appeared. A necessary auxiliary for high flight, and otherwise an advantage, the supercharging impeller is driven either by gears from the engine or by an exhaust-gas turbine. With extremely few exceptions, all impellers whether gear-driven or turbine-driven, and all exhaust-gas turbine wheels applied to planes in this country have been manufactured by the General Electric Company from Moss's designs.

HIGH-PRESSURE AND RESUPERHEATING TURBINES

If the dates of manufacture of the early 600-lb and 1200-lb turbines are compared with the dates when new information was rendered available on the properties of steam, it will be seen that the investigation had been started none too soon. The race was close between the availability of accurate information and the actual manufacture on the basis of the best interpretations Keenan could place on the experiments available.

The period of Coolidge prosperity was at hand. During the 1920's a very considerably greater kilowatt capacity of turbines was manufactured by the General Electric Company than in the entire 20 years previous, in fact, almost twice as much. Beginning in 1924, this includes approximately half of the hundred largest turbines in the world, of which about a quarter were made by close to a dozen manufacturers in Europe.

There were a number of notable trends: Resuperheating, extraction for feedwater heating, higher pressures, higher temperatures, and compounding for larger sizes. All of these activities have a single result to which the government records bear witness—the reduction of the average consumption of coal for the generation of electric power from 3 lb per kwhr in 1920 to less than 1.5 lb per kwhr at present.

Before modern high-temperature alloys were available, the approach to high-pressure operation necessitated intermediate resuperheating of the steam to avoid excessive moisture in the exhaust. Resuperheating has always been advantageous from the point of view of fuel economy, the nonthermodynamic im-

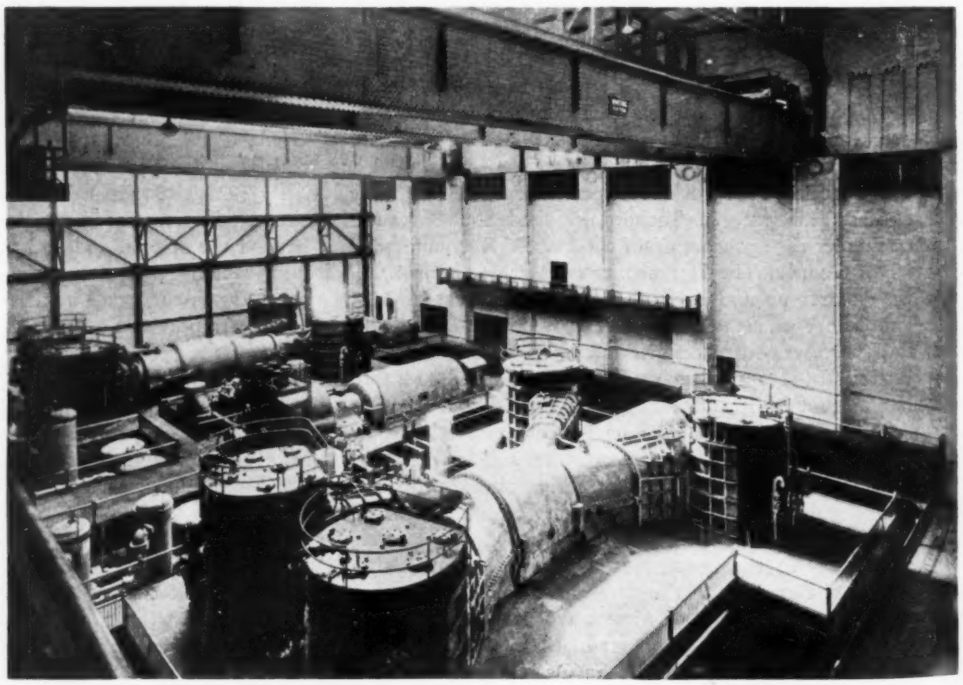


FIG. 14 208,000-KW, TRIPLE CROSS-COMPOUND TURBINE FOR STATE LINE GENERATING STATION NEAR CHICAGO

provement in efficiency due to moisture elimination being practically as important as the theoretical cycle improvement and in addition thereto.[10] However, resuperheating has not been an unmixed blessing. Steam resuperheaters have been used to avoid the large pipes back to the boiler room, but the fuel saving is not so great with steam resuperheat. Just now, in 1936, initial temperatures have advanced so as to preclude an excessive moisture content in the exhaust steam without any resuperheat even at 1200 lb per sq in. initial pressure. But the progress toward more efficient cycles may bring resuperheating back into favor again in one form or another in the attempt to approach isothermal absorption of heat.

In 1924, the first 600 lb per sq in. stations were placed in service at Philo, Ohio, and Crawford Ave., Chicago. These were started with 550 lb per sq in. at the turbine, but this was later raised to 600. The Philo machines, Fig. 12, were single-cylinder 35,000-kw, 1800-rpm turbines, the shells made with pipes for the steam to go out and come back. The Crawford Ave. 60,000-kw turbine was the largest machine of its day, with two cylinders, the high-pressure running at 1800 rpm and low-pressure at 1200 rpm.

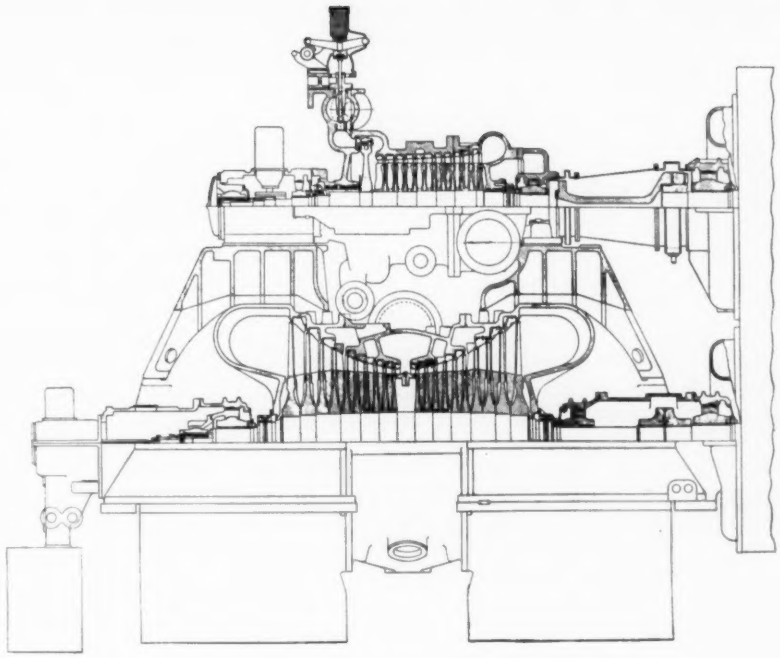


FIG. 16 110,000-KW, 1800/1800-RPM VERTICAL COMPOUND TURBINE FOR FORD MOTOR CO.

In 1925 the first turbine for 1000 lb per sq in. pressure was started in Boston, Fig. 13. It was cautiously rated 2400 kw but there was enough uncertainty as to the specific volume of high-pressure steam to make accurate prediction of the amount of steam the nozzles would pass rather uncertain. A year later the pressure was raised to 1200 lb per sq in., and this turbine carried 3000 kw.

The Boston machine was soon followed by the Milwaukee 7000-kw, 1200 lb per sq in. machine. Both of these machines were what would now be called "superposed" turbines. They exhaust into existing steam mains and drive low-pressure turbines. Tests on these machines settled all "croaking" that improvement in cycle efficiency would be more than offset by excessive leakage and internal losses. They were built with a multiplicity of stages, assuring low velocities and comparatively long buckets, and the internal efficiency is actually better than that of the 30,000-kw turbines into which they exhaust at a pressure of between 300 and 400 lb per sq in.

The mechanical design of these machines, made good for twice the highest pressure previously used and three times the pressure of only two years before, was not without its problems.

Specially designed flanges with a depth approaching the internal radius of the shell enabled these casings to be built with a horizontal split for dismantling in the orthodox manner.

All uncertainty as to the satisfactory performance of the high-pressure packing was settled by an intermediate leak-off to exhaust pressure, suggested by J. H. Doran, so that, so far as the station was concerned, the high-pressure packing handled no greater pressure drops than in the standard pressure machines.

[10] "The Increase in Thermal Efficiency Due to Resuperheating in Steam Turbines," by W. E. Blowney and G. B. Warren, Trans. A.S.M.E., vol. 46, 1924, pp. 563-593.

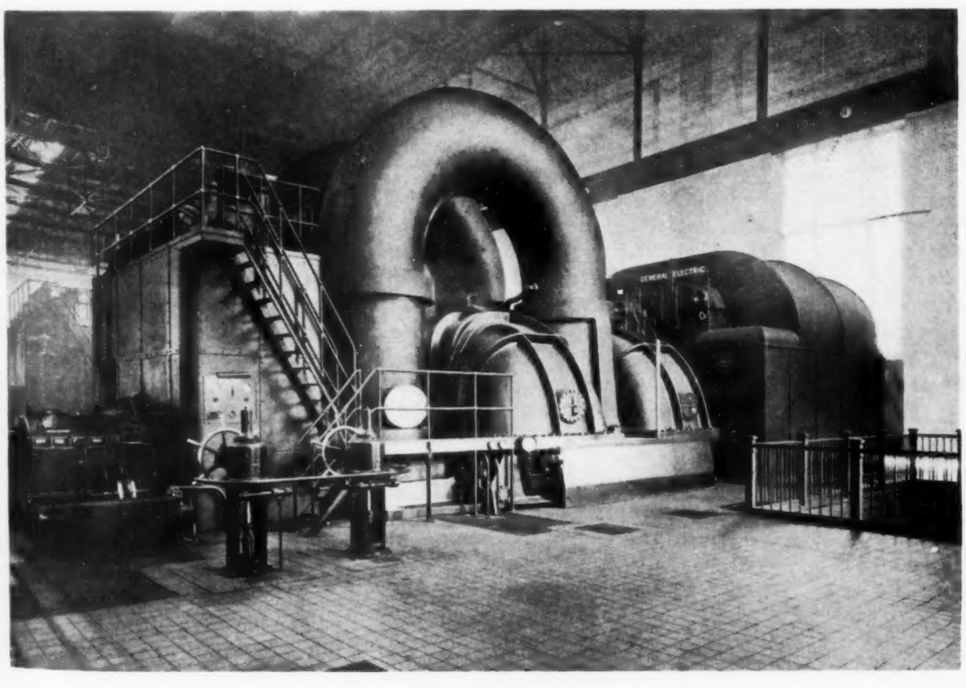


FIG. 15 TWO 160,000-KW, 1800-RPM TANDEM COMPOUND TURBINES, BROOKLYN EDISON COMPANY

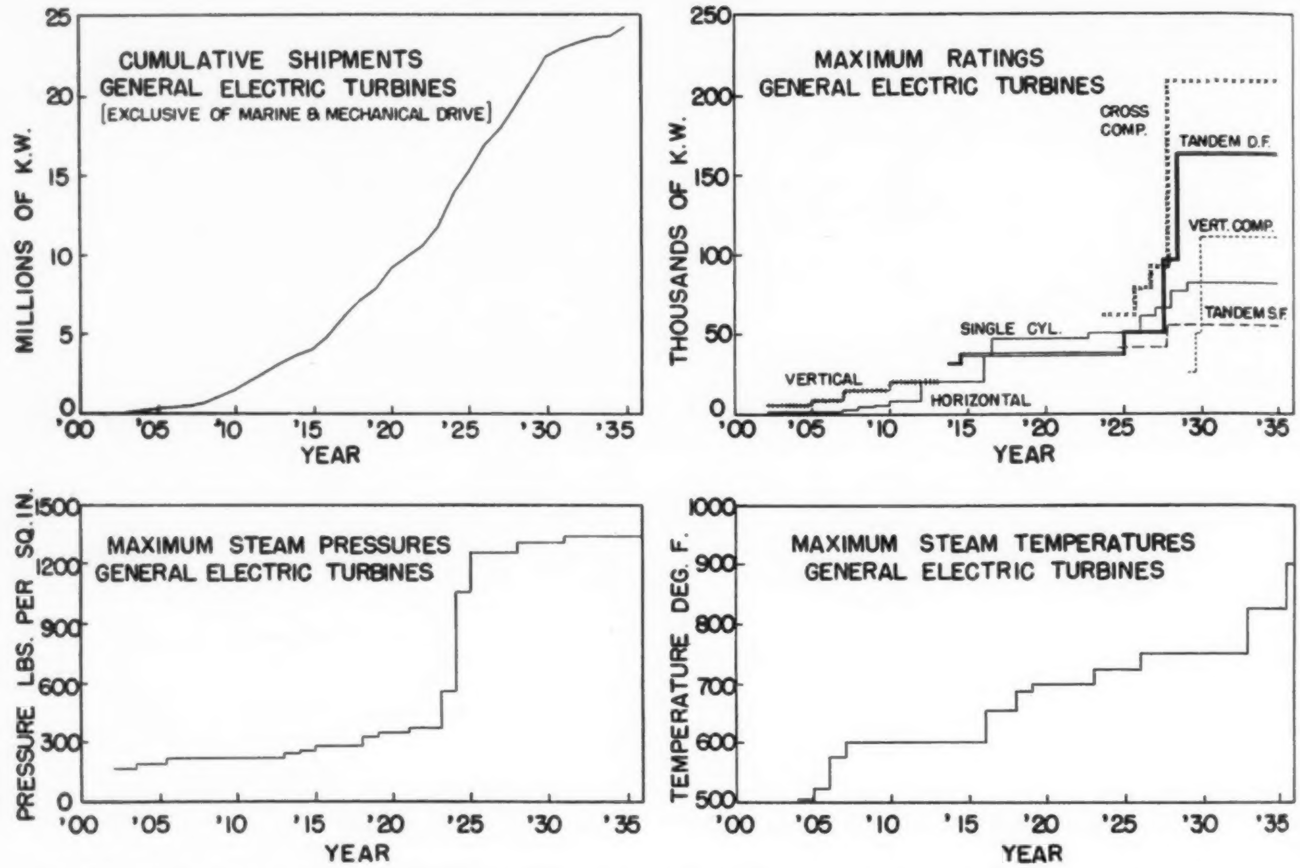


FIG. 17 CUMULATIVE SHIPMENTS OF GENERAL ELECTRIC TURBINES, MAXIMUM RATINGS, PRESSURES, AND TEMPERATURES, 1900–1936

FEATURES OF MECHANICAL DESIGN

The high-pressure Boston machine was the first to be built with a "solid rotor," the wheels being milled out of a solid forging, a construction used extensively in the years following.

The increasing temperatures throughout these years had not been without special problems. In 1919, Junggren patented his radial-pin bushing. This assured the true running of wheels subjected to high temperatures regardless of possible expansion. A size-and-size bushing was fitted to the bore of the wheel during manufacture and assembled with nicely fitted radial pins extending into the hub of the wheel. The whole was shrunk on the shaft like any other turbine wheel. Under starting conditions when the wheel may be hotter than the shaft, the bushing maintains shaft temperature and stays tight while the expanding wheel remains concentric and runs true without disturbing balance, even if all shrinkage between it and the bushing temporarily disappears.

As late as 1920 water pipes were embedded in bearing metal to cool the bearings. A patent which was issued in 1921 to J. L. Roberts (with whom most operators are well acquainted) provided a new arrangement of grooving, reversing the direction of flow, that enabled complete cooling to be effected by the lubricant itself. No more water-cooled bearings were built.

For preservation of close clearances, it was necessary for turbine casings to be supported in such a manner that increasing temperatures would not alter their alignment relative to the rotating parts. To accomplish this, horizontal supporting arms on the high-pressure head were placed at bearing level, preserving vertical alignment, while vertical guides above and below the shaft assured horizontal alignment. The adoption of this improvement was due largely to Doran's effort.

Ease of bolting was facilitated by the use of hollow bolts so that a heating element could be used to expand them temporarily and enable exact adjustment.

THE ERA OF LARGE TURBINES

The years following saw the increase in size of cross-compound units to 208,000 kw, the largest single unit in the world at present. Fig. 14. This is the State Line machine with one high-pressure and two low-pressure double-flow cylinders exhausting into eight vertical condensers. Single-cylinder machines were built up to a maximum size represented by the two 80,000-kw, 1800-rpm machines of the Buffalo General Electric Company placed in service in 1930 and 1931, while tandem double-flow units were built to double that capacity. One such machine for the New York Edison Company operates at 1500 rpm, while the two 160,000-kw, 1800-rpm units placed in service at Hudson Avenue, Brooklyn, in 1932 drive 200,000-kva generators, the largest that have ever been built anywhere. These Hudson Avenue turbines concentrate 125,000 kw in their high-pressure cylinders alone. See Fig. 15.

Condensing turbines for operation with 1200 lb per sq in. initial pressure and 750 F initial temperature were built as cross-, tandem-, or vertical-compound machines to provide for intermediate resuperheat to a like temperature, the highest for which materials were available. With all of these machines noteworthy, it is difficult to select the right ones for attention in a brief survey of this nature. The cross-compound machines were arranged with the high-pressure elements operating at

3600 rpm and the low-pressure elements at 1800 rpm. The smaller dimensions of the high-speed elements were conducive to efficient nozzle and bucket design. These considerations correspond with those that dictated 1200 rpm for the low-pressure elements in the large machines at Crawford Ave.

Some tandem machines were built for those who desired to have a single generator. There were also a number of vertical compounds, the high-pressure element being mounted directly over the low-pressure element. When the high-pressure element ran at 3600 rpm, it could be mounted complete with its generator on top of the 1800-rpm generator connected to the low-pressure turbine.

But the Ford Motor Company 110,000-kw vertical-compound machine has two equal generators both running at 1800 rpm. The first of these, Fig. 16, was placed in operation in 1931 at 1200 lb per sq in. gage pressure, 750 F temperature, with steam reheat to 550 F. This machine concentrated more power in a cubic foot of station space than any other machine then built. Another machine, substantially a duplicate, has just been installed for operation at 900 F without reheat.

Throughout this period of growing sizes there was a gradual increase in the provisions for the extraction of steam for feed-water heating. In the ten years between 1918 and 1928 practice changed so as to provide not just one port for "bleeding" but three or four or five. While pressures went up in a single jump to 600 and 1200 lb per sq in. gage, temperatures increased but gingerly and stuck at 750 F in 1926.

These various influences are illustrated by a set of charts which the author prepared for the World Power Conference, Tokyo, in 1929. Fig. 17 shows these charts brought up to date.

BUCKET TROUBLES OF 1928

While this record is for the most part a record of achievement, it is impossible to avoid acknowledgment of the accumulating frequency of bucket troubles which beset General Electric turbines in 1927 and 1928. The increasing sizes of turbines called for longer buckets. These were easily designed for centrifugal stresses and made nonresonant as regards all serious types of critical vibration. The situation which occurred was, in a small degree, a repetition of what had happened on wheels, but, of course, involved a new element, a certain amount of forced vibration at moderately high frequencies. At the most, not more than one wheel in a hundred was reported for bucket trouble, however trivial, during the course of a year. But the annoyance was costly to the operators and intolerable.

Vibration stimuli had increased with increasing wheel and bucket power loadings and statistical analysis showed all chronic cases occurred when such high loadings were associated with low transverse section moduli. A skeleton theory was formulated by the author involving a resonance factor corresponding somewhat to the impact factor used in railway loadings, but capable of being much larger. Statistical analysis covering literally 10,000 wheel-years of service enabled limits to be fixed which would preclude any repetition of the chronic troubles in new designs. Since 1929, Heckman has designed all new buckets according to these standards, and they have proved free from trouble.

MATERIALS AND MANUFACTURING PROCESSES

Buckets for the original Curtis turbines were milled out of the solid metal of the wheel rim or out of segments of metal which were then riveted to the wheel. This manufacturing process was then regarded as very important. The use of individual buckets dovetailed to the wheel came later, bronze and monel being used for bucket materials. One of the most important incidents in the history of turbine materials was the adoption of nickel steel for wheels and buckets. Up to the time of the war 600 F had been the limit for temperature. The rise to 700 F in 1920 forced realization that cast iron was unsuitable for use at such temperatures. Cast-steel shells were made thereafter for all temperatures above 500 F.

Diaphragms were made by casting-in nozzle partitions formed from rolled plates bent to shape. In the low-pressure stages these were of cast iron. In the hotter stages with higher pressure drop they were made of cast steel. The heyday of Steenstrup's copper-brazing process was from 1921 to 1928. The earliest forms of efficient high-pressure nozzles were made by assembling the partitions of accurately shaped airfoil sections with spacers between and uniting them to their side walls by copper brazing in a hydrogen furnace. Accurate performance on the part of the factory was necessary, since "sloppy" fits resulted in joints of subnormal strength, but good nozzles were secured.

W. J. Delles, with a background of foundry experience, patented a high-efficiency nozzle in which the partition, with the part of the side wall adjacent to the throat integral, was cast into the inner web and outer ring. Then came modern arc-welding.

From the war time up to 1925, and after, nickel steel was used extensively for buckets.

The General Electric Company had developed in 1915 "Turbuck" metal containing 12 per cent chromium and under 0.12 per cent carbon. Buckets of this material were installed in the last stage of its 10,000-kw power-house turbine manufactured in 1915. This turbine was placed in operation the following year and has been running for the 20 years since with these same buckets in it. Inspection in 1920 disclosed a few buckets with seams, although the stage as a whole was in excellent condition. It appeared difficult to secure this material free from this defect and its general application was further delayed. In 1924 it was used in small quantities for packing sleeves with a view to establishing a satisfactory source of supply before using it for buckets. It still had to be watched carefully for seams. Its first extensive use in General Electric turbines was in 1925, but its application was then rather cautiously restricted to those stages subject to corrosion but free from vibration. By 1929 the uniformity of the commercial product had so improved that it was in universal use for the entire steam path.

It was evident in 1928 that further advance in initial temperatures would be impossible without materials capable of resisting distortion at high temperature. Early in 1929 a program for creep-testing prospective materials at high temperature was begun, and seven furnaces with a capacity of 28 test bars of 10 to 12 in. gage length were placed in service in 1929 and 1930. This program, pursued vigorously throughout the depression years, has yielded knowledge on how to produce molybdenum alloys with confidence that they will resist distortion at temperatures of 900 and 1000 F. The mere presence of the molybdenum is not enough.

In the meantime, the soundness of all materials and processes was further assured by magnetic and X-ray examination. The first outfit for magnetic examination of wheel forgings was installed in the General Electric factory in 1920, and for many years all wheel forgings have been examined magnetically for hidden flaws. Since 1932 each and every individual bucket has also been so examined.

X-ray equipment of 200 kvp became a regular shop tool in 1931, and this has been doubly important in assuring the soundness of castings and in training welders to make perfect

joints. Although the original equipment is still in use, higher voltage apparatus was added later on.

GENERATORS

While this narrative is intended to be a record of progress in the steam-turbine art, it would be incomplete without some reference to the electric generators, the driving of which is the main function of the steam turbine. Originally multipolar and slow-speed, the earliest generators were designed under the supervision of H. G. Reist. Growing by leaps and bounds with the turbine, it was more than once uncertain whether the maximum-size limit was on the mechanical or the electrical side of the coupling. W. J. Foster was associated with Mr. Reist, while in recent years the largest machines ever built have been designed under the direction of M. A. Savage. Although usually regarded as the jobs of the electrical engineer, it seems that most of the important problems aside from those of insulating for increasing voltages were problems of a mechanical nature.

Fifteen years ago closed ventilation systems were recommended and in 1923 condensate was used for cooling, thus returning to the boiler certain of the generator losses. Closed ventilation systems became standard within a short time, and with them General Electric surface air coolers came into common use. These were designed and manufactured under the supervision of A. R. Smith, for the past six years managing engineer of the turbine department.

In 1922 a 3380-kva generator was operated in the General Electric factory with hydrogen as a cooling medium, and the classical paper on this subject by Knowlton, Rice, and Freiburghouse appeared in A.I.E.E. *Journal* for July, 1925. The light-density hydrogen suffices practically to eliminate ventilation loss, which, with air-cooled machines, constitutes one of the largest losses.

Ten years ago the 62,500-kva, 1800-rpm generators for the Richmond station of the Philadelphia Electric Company were the largest and most efficient machines then in operation at 1800 rpm. Incorporating specially improved ventilation arrangements, the efficiency was slightly better than 98 per cent.

The following year construction was undertaken on the 160,000-kw, 1500-rpm generator for the New York Edison Company, at that time, the largest ever contemplated by the General Electric Company. This was the first double-winding machine built.

The largest generators in operation are the two General Electric 160,000-kw, 200,000-kva machines in the Hudson Avenue Station of the Brooklyn Edison Company, operating at 1800 rpm. These have separate external blowers, but the entire ventilation and cooling system is totally enclosed. These are still the largest generators in the world.

DEPRESSION YEARS

Perhaps the depression years should form no part of this narrative. To some future writer it may appear as a smaller incident than to us at present. There have been changes. Junggren died last year. Eveleth and Delles had already passed on. But the younger organization is intact.

A year ago the weekly reports of power output for the country as a whole began to exceed the peak loads of 1929 and 1930. This year the power generated from fuel is already well in excess of the 1929 peak for fuel power and, at date of writing, October, 1936, the maximum month for fuel power is still uncompleted.

Awakening industry is asking for high-pressure machines at higher temperatures than ever before and *they will be built*. But a discussion of these designs is not history—that is for the current technical press.

In conclusion, the author feels it necessary to recall that this is at best but a fragmentary sketch. The many incidents recalled to him by eleven associates who read the manuscript during its preparation are gratefully acknowledged. While names have been freely mentioned where it seemed most appropriate, it is impossible to hope that correct credit has been properly weighed and duly assigned.

SIR CHARLES A. PARSONS AT THE GENERAL ELECTRIC TURBINE FACTORY, SCHENECTADY, 1924
(Left to right, E. H. B. Anderson of the Parsons Company, C. E. Eveleth, Sir Charles A. Parsons, E. W. Rice, Jr., Lady Parsons, E. E. Gilbert, O. Junggren.)

MANAGEMENT TECHNIQUES

Discussed at 1936 A.S.M.E. Annual Meeting

As THE result of a new plan for reporting the less formal papers and discussions presented at meetings of the Society, a brief account of the sessions at the 1936 Annual Meeting of the Society which were sponsored by the Management Division, either individually or in cooperation with other organizations, appears on this and the following pages. No attempt has been made, in covering the different sessions, to do more than give a brief statement of the subject matter of the various papers and the highlights of the discussion following their presentation. All of the sessions were well attended, the papers were enthusiastically received, and the discussions were participated in by many of the audience and brought out numerous interesting and informative points.

Time and motion study, distribution, management-plant layout, dealing with workers, organization and management of maintenance, and employee training were the general topics for a dinner at Midston House which was followed by an evening session at the Engineering Societies Building, four sessions at the Engineering Societies Building, and two luncheons at Midston House. The organizations that cooperated with the Management Division in planning and conducting the various sessions include the Society's Committee on Education and Training for the Industries, the American Marketing Association, the Society for the Advancement of Management, and the Personnel Foundation.

TIME AND MOTION STUDY

On Monday, November 30, a dinner was held at Midston House under the auspices of the Management Division. This was followed by a session in the Engineering Societies Building at which research work in connection with time and motion study and some applications were discussed. At the session, which was presided over by Dr. L. M. Gilbreth, papers were presented by R. M. Barnes, University of Iowa; Miss G. C. Ford, Grove City (Pa.) College; and A. Williams, Jr., Hood Rubber Company, Watertown, Mass. The subjects covered investigation of simple hand motions, motions in typing, and motion study as a basis for establishing employee training.

Special apparatus that recorded hand motions on a sheet of paper moving at a known uniform velocity across a table top was developed in the time and motion-study laboratory of the University of Iowa, where Mr. Barnes is professor of industrial engineering. The particular motion described in the paper was a controlled back and forth motion of the right hand directly away from and toward the operator for distances of 5, 10, and 15 in. in each direction using a mechanical stop and also requiring the operator to match a mark on the moving carriage with one on the slide on which the carriage traveled. After instructing the operator in the test procedure and permitting him to make 30 complete unrecorded cycles, approximately ten complete hand motions were recorded on the moving paper.

Based on tests of 28 operators, nine conclusions were drawn regarding the influence of length of motion and type of stop on the time required to make the various motions, the percentage of time required to accelerate and decelerate the hand, the time spent in motion at a constant velocity, and the percentage of total motion time consumed in changing the direction of motion. As the last required a relatively large proportion of total cycle time, 5 to 24 per cent, the conclusion was drawn that continuous curved motions of the hand should be used in industry instead of abrupt changes in direction. These findings were utilized in developing a new method of folding small sheets of paper by hand in which the time for creasing the fold was cut approximately in two and the time for the complete operation reduced from 0.058 to 0.033 min.

An investigation of the component parts of the motion of the right hand along four constrained motion paths was also described. Each path was 10 in. wide and 10 in. high, but the upper halves differed in each case, being square corners, round corners of 5-in. radius, an octagon, and round corners of $2^1/_2$-in. radius, respectively. The highest average velocity, 91.8 fpm, was attained on the last path, and the lowest, 73.1 fpm, was attained on the path with octagonal upper corners.

In her paper, "Study of Motions in Typing," Miss Ford presented four conclusions as follows:

(1) Fast motions are shorter and faster than slow motions and, therefore, cannot be made in the same path. Thus normal speed in stroking should be used from the start to develop regular typing patterns with correct motions, speed, and time.

(2) Great advances will be made in the typewriting field as more and better use is made of those bodies of knowledge concerning the individual, such as biology, psychiatry, psychology, and sociology.

(3) Learning a scientific keyboard is much easier because hand and finger loads are balanced, one-hand words are eliminated together with awkward hurdles, reaches, and stroking patterns with the same finger successively. Therefore, better motions, combined with greater skill and satisfaction, help to make a speed of 50 words per minute possible in half the time now required with the present keyboard.

(4) Schools and other institutions should be able to spread the use of typing facilities to perhaps twice as many students when a scientific keyboard is used. This, in turn, would effect a considerable saving in student time, as well as in money cost for instruction and equipment.

Mr. Williams, in his paper, discussed the influence and value of motion study to employee training and personnel relations. He stated that more advanced and efficient methods of training must be utilized to meet the current shortage of skilled labor and that the greatest opportunity for and challenge to motion study was presented by the training problem of the semiskilled workers. Employee training consisted of three steps: Knowing the job, recording the one best way as standard factory practice, and the actual training of the employee.

Factors that are essential to a basis of sound employee relations were (*a*) a proper place in which to work, (*b*) proper training for the job, and (*c*) a fair and equitable wage for reasonable performance, including effective utilization of their energy and motions, and motion study could be a useful and essential tool in attaining these results. Success of any motion-study program depended largely on the attitude adopted by industrial executives toward it, and sustained interest on the part of this group cannot be expected until management realizes the value of this tool and understands what it really is and how it can be applied. The importance and value of motion study to the work of the employee should not be undervalued, and, once the employee realizes that this device can

be used effectively in benefiting working conditions and insuring fair and equitable standards of performance, he will become its most enthusiastic supporter.

DISTRIBUTION

Following the Distribution luncheon that was held on Wednesday, December 2, under the auspices of the Management Division and the American Marketing Association, two papers dealing with product and sales research were presented by L. Chalkeley, director of research, Benton & Bowles, Inc., New York, N. Y., and W. M. Bristol, Jr., production manager, Bristol-Myers Company, Hillside, N. J. The former discussed, from a sales and advertising viewpoint, the problems of attempting to determine the consumers' desires while the latter explained the subject from the production angle.

Dr. Chalkeley described the complete change of base on the question of colored gasolines which resulted from the development of an automotive fuel that could be used in high-compression engines. Originally the oil companies believed that the public would not buy a gasoline which was not water white; now, however, gasolines with yellow, red, green, blue, and orange dyes are regularly marketed, the colors signifying either the grade or the brand. The refiners had made fallacious assumptions about what the public did and did not want, while the automobile companies attempted to learn what the public wanted and to build products which the public would buy and prefer to other products that it might have. This represents two different schools of thought on consumer desires. Today, manufacturers realize that a product, to have consumer acceptance, must be designed to meet the public's taste and the product most nearly fulfilling that requirement is the one purchased instead of another which most closely meets laboratory specifications or good engineering practice. Work upon production problems is fundamentally inefficient and uncertain in its outcome unless a manufacturer knows what the public wants and what it will purchase.

As an example of correct and incorrect ways of making a survey, Dr. Chalkeley cited the case of two surveys conducted in Mexico City after a soap of a new color had been sold there for one year. One survey was conducted by local organizations that had been interested in the sale of this soap; the other, by an agency in New York that was concerned with possible exploitation of the soap in the United States. In the first survey, 81 per cent of those interviewed were users of the product, and 11 per cent of these voluntarily mentioned the change in color and commented upon it. Two thirds of the remaining users, upon having their attention called to the change, replied that they had noticed it and liked it, 15 per cent resented the reminder and did not like the change, and 13 per cent were indifferent. The second survey found that only 36 per cent of those interviewed used the soap and 7 per cent of these had noticed the new color. On the basis of these two surveys, the value of the change of color is much less than one would have been led to believe if those interviewed had been asked immediately regarding that specific change, which Dr. Chalkeley considered a desirable feature.

Results of the type obtained in the first survey would not carry much conviction to the manufacturer who was asked to purchase the invention making this improved, more beautiful, and more stable color possible. In addition to interpreting the results of a survey, the manufacturer must consider the possibility of unfavorable results following this change in color, such as increased costs, difficulty in manufacturing, distribution troubles, using a different group of salesmen, or a change in advertising.

Mr. Bristol confined his paper to possible improvements in existing products and discussed some experiences of his organization in that respect. Two sources of changes in products or packaging or both were the classification and tabulation of all complaints and returns and a system requiring salesmen to purchase items in the open market periodically and forward them to the company's laboratory for examination. The latter has indicated that, in many cases, a product which apparently was considered satisfactory by the customer differed from what the factory thought was being sold.

Effect of climatic conditions on sales was mentioned as one of the problems that a factory must consider. Research to insure uniformity of a product regardless of these conditions is the remedy. Closely allied to this was the case of a product whose stability was affected by climatic conditions. Research indicated the possibility of improving the closure used on the package with a definite increase in the sales of a size which was formerly not in demand.

Before new packages and products are placed on the market, the production man should be encouraged to submit his ideas. In many cases, his knowledge of economical methods of packaging and handling and the proper containers and closures to be used may mean the difference between the success and the failure of a product. As an example of this, Mr. Bristol cited the case of a product that was formerly sold in bulk for filling smaller bottles, a practice that encouraged substitution of a competitive product. To offset this, efforts were made to find a container which could not be refilled and would be more or less destroyed at the time of using. Glass, normally the ideal container, could not be used on account of the expense as well as the difficulty of finding a container on the market that met the requirements of the situation. The solution of the problem was a collapsible metal tube with a special tip or rat tail in place of the conventional cap, which was designed by an engineer of the company from whom Mr. Bristol's firm purchased its collapsible tubes.

MANAGEMENT-PLANT LAYOUT

A brief account of the Management-Plant Layout session, which was held on Wednesday, December 2, under the joint auspices of the Management Division and the Society for Advancement of Management, has been prepared by W. H. Kuschnick, of the Anchor Cap & Closure Corp., Long Island City, N. Y., who writes as follows:

The economic consideration necessary to a proper layout, as well as the important part motion and time study played in the picture was readily accepted by those attending. Discussion, all of which was oral, centered principally on the importance of securing foreman cooperation and the cost and technique of presenting the contemplated improvements.

H. B. Leach, head of the standards department, Prophylactic Brush Company, Florence, Mass., told of his company's program for training younger men selected from the assistants and understudies of the operating foreman. Aside from the development of a motion consciousness among these younger men by giving them a course in time and motion study, definite emphasis is placed on instilling in them the concept that they and their supervisors, the foremen, are the ones to originate improvements in their respective departments. Use of the process chart and planning board was further elaborated on by Mr. Leach, during which he pointed out that, each year, the chart is compared as an inventory of improvement and a program set for possible future improvement.

Some questions were asked in connection with the cost of motion-study equipment. A. H. Mogensen, industrial-management consultant, explained that the necessary equipment could be obtained for as little as several hundred dollars. He,

however, pointed out that to "buy as you go" was wiser because even with the simpler necessities, sufficient cost-reduction can be effected to warrant additional investment in equipment as refinement requires.

The use of three-dimensional models was explained by T. M. Perkins, of the Bridgeport Brass Company. F. J. Van Poppelen, industrial engineer, Remington Arms Company, Bridgeport, Conn., stressed the need for simplifying and reducing the cost of some elaborate methods of presenting the layout modifications. Mr. Mogensen, in turn, felt that the better visualization through the use of small models in three-dimensional setups for selling the improvements to supervisors and executives was well worth the trouble and expense.

DEALING WITH WORKERS TODAY

On Thursday morning, December 3, a joint session was held under the auspices of the Management Division, the Society for Advancement of Management, and the Personnel Research Foundation. Only one paper, "Modern Principles and Practice of Manufacturing Organization in Employee-Employer Relationship," was presented at this session. The subject was opened by W. G. Marshall, vice-president, Westinghouse Electric & Mfg. Co., and was discussed in its various applications by the following representatives from the same company: T. I. Phillips, general works manager; J. H. Priest, supervisor of works industrial relations; and R. M. Rumbell, manager of meter division. A résumé of the paper and the discussion that followed its presentation has been prepared by A. J. Schwertfeger, as follows:

In the past, many industrial organizations thought that questions of employment, wages, rates, working conditions, and employee welfare were subjects to be discussed only by the management, and the employee abided by such decisions as were handed down to him. The modern trend in employee-employer relationship is to let the worker express his feelings and suggest ways of improving his working conditions and general welfare. This is done through employee representation on a works council or similar organization where representatives from both the workers and the management meet and discuss grievances. These employee-representation plans have been most successful in those companies where no attempt has been made by the management to force its opinions on the workers. Hence, the workers through their representatives are compelled to think for themselves instead of having the management do it for them.

Another practice that has come about through the new employee-employer relationship is the current effort on the part of management to keep the employee informed on company plans and policies. Probably the most widely discussed topic at the works council meetings has been wages and rates. Many serious difficulties have been overcome peaceably because an agency was set up whereby such matters could be discussed impartially without the former stigma of being an agitator or a complaining crank. Several progressive companies are now studying, or have adopted, plans whereby the workers share in the net earnings whenever they exceed a predetermined figure.

In the oral discussion that followed, the general feeling was expressed that workers should not be "educated" to qualify as employee representatives on the works council. Criticism was also voiced of the term "education" in connection with employee representatives, the feeling being that such instruction, even when given with good intentions, might be construed as propaganda.

One discusser said that the employee representative should receive the same courteous and private consideration from the general manager as any other person who has important business with the management of the company. Other views expressed indicated that a closer feeling of cooperation should exist between management and worker representatives.

In answer to several questions regarding the Westinghouse wage and salary-rating plan, Mr. Roberts, of the Westinghouse Company, explained that all positions from the lowest to the highest were included in the plan. Approximately 300 different positions were classified into the five divisions of (*a*) unskilled, (*b*) elementary supervisory, (*c*) executive, (*d*) administrative, and (*e*) policy forming. Key limits or guides are set up for each division, and salaries are paid according to the limits for each division. This rating system is fully explained to each employee. He also explained that, in the Westinghouse employment system, every worker is interviewed when being transferred or dismissed.

A short discussion covering the relationship between the foreman and the specialist or consultant, who is occasionally called in, brought out the fact that the specialist was merely assisting the foreman. In all cases, the foreman should be made to feel that he still has complete control of his department.

ORGANIZATION AND MANAGEMENT OF MAINTENANCE

J. A. Jacobs, of the Colgate-Palmolive-Peet Company, Jersey City, N. J., writes concerning the luncheon meeting on Organization and Management of Maintenance, which was held at Midston House on Thursday, December 3.

The meeting was attended by a widely diversified group from various industries and professional activities, which was well distributed geographically. At the luncheon, L. C. Morrow, editor, *Factory Management & Maintenance*, New York, N. Y., spoke briefly voicing his appreciation of the apparent lively interest in the subject of maintenance as evidenced by the attendance of 40 and expressing the hope that the group would take full advantage of the session to discuss thoroughly the particular subjects announced for the meeting and any related topics that might be brought up in the discussions.

Four timely subjects relating to maintenance were presented by four speakers, and the discussion at the end of the session was participated in by many of those in attendance.

W. O. Lawson, of E. I. du Pont de Nemours & Co., Inc., Arlington, N. J., in speaking on "Preventive Maintenance" outlined the benefits that can be realized by taking precautions against equipment failures, such as having a trained experienced mechanic make careful inspections of machinery. Specific examples based on his experience were cited, one of these being a certain piece of equipment on which parts repeatedly failed. Cooperation with the manufacturer improved the machine and eliminated costly failures and maintenance. He also stressed the importance of proper lubrication, explained the benefits of employing a lubrication engineer if the plant was large enough to warrant this expense, and pointed out the information and technical advice regarding the proper application of lubricants which the oil companies were glad to give their customers.

W. C. Zinck, of the North & Judd Mfg. Co., Brooklyn, N. Y., explained a record system for accounting and reporting maintenance costs which was used by his company and described maintenance order and job tickets. The weekly distribution of maintenance labor listed all issued, uncompleted, and completed orders which were grouped under each of the craft classes. In addition, the average number of hours per repair order, the hours spent on maintenance work and the mechanics so employed, and the time spent on blanket orders are shown. The maintenance payroll is similarly distributed to show the type

of work, and labor cost of repairs and replacements is allocated according to classes of machinery.

"Planning for Major Maintenance Jobs" was discussed by A. Vaksdal, plant engineer, Corning Glass Company, Corning, N. Y. He outlined a plan that he favored for giving information regarding jobs to the various craftsmen. This plan utilizes a card rack at the time-clock center, which shows the jobs on which work is being done with the names of the different mechanics working on each of these, the next job to be undertaken, jobs waiting, and jobs completed. Some simple indicator showing the state of jobs being done, waiting, and completed is important, but preparing well ahead of time for the next job is most important. He emphasized the point that, when mechanics have to pester the foreman for their next job, management is sadly inefficient.

J. I. Thompson, of the Bristol-Meyers Company, Hillside, N. J., discussed "Procedure and Methods Within the Mechanical Department" and explained that in certain manufacturing or packing departments of his company, separate mechanical services were organized for the individual departments and were supervised by the manufacturing foremen of these departments.

In the absence of A. E. Windle, of the Kroger Grocery & Baking Co., Cleveland, his paper on "Education of Foremen to Produce Cost-Conscious Employees" was read from the floor.

The discussion that followed covered all five papers, and authors were called upon to answer many questions propounded by the audience. R. M. Matson, of the International Business Machines Corporation, Endicott, N. Y., stressed the importance of suitable records in engineering departments and offices to facilitate locating drawings and stated that many old-type drafting rooms follow the consecutive number system.

W. C. Brinton, president, Terminal Engineering Company, New York, N. Y., described his experiences in maintenance work for certain of the heavy industries where good planning to eliminate high maintenance costs is sadly lacking. He also expressed the hope that the maintenance group represented at the meeting could inaugurate further discussions of the subject and perhaps establish a close contact with the time-study group which might be studying this same subject.

TRAINING PEOPLE TO BE SKILLED WORKERS

On the afternoon of Thursday, December 3, a joint session was held under the auspices of the Management Division, the Society's Committee on Education and Training for the Industries, the Society for Advancement of Management, and the Personnel Research Foundation. Two papers on the general subject of Training were presented by F. E. Searle, superintendent of Ford schools, who discussed the selection of apprentices and their training as machine operators, and C. G. Simpson, assistant personnel manager, Philadelphia Gas Works Company, whose topic was the training of adult workers.

The Ford apprentice training course had its real inception in 1913, Mr. Searle said, when a group of toolroom employees who realized their need for a better knowledge of mathematics and drawing organized a class with one of them as instructor. From this small beginning, has grown the educational system of the Ford Motor Company, which now comprises (*a*) the apprentice school, organized in 1915; (*b*) the Henry Ford Trade School, which opened in October, 1916, with six students; and (*c*) the training school, opened in June, 1935. These schools give young boys finishing grammar school, high-school graduates, or employees ambitious to learn a trade a chance to train for advancement.

The Trade School enrolls boys between the ages of 12 and 15, trains them on the cooperative basis, and, upon their being graduated at 18 or 19, they are offered jobs in the Ford plant. In this, the first cooperative school for young students, one week is spent in the classroom and the next two in the shop, and the academic training is closely correlated with the shopwork. Effort is made to give the boys as varied an experience as possible in many of the 25 departments of the shop, and, with that end in view, a few boys are transferred every day to new tasks. This method of instruction enables a boy entering the shop to begin useful work with little explanation on the first day. This shopwork is productive, and includes repairing of safety goggles and small tools by the younger students, precision-tool reconditioning by these with more experience, and the manufacture of tools by the older boys. In the last year, the value of this work amounted to $1,700,000, or practically sufficient income to operate the school.

Enrollment in the Training School is confined to high-school graduates between 18 and 20 who are given experience on typical toolroom work. The primary object of the school is to give an opportunity for a brief training to boys wishing industrial work before transfer to a permanent location. Its graduates are absorbed by almost every Ford activity.

Graduates of these two schools form the larger part of the students in the Apprentice School. Attendance at this school is compulsory for all apprentices and optional for other employees. The former group receives both classroom and shop training, while the other students attend only those classes for which they are prepared. In the shop, the apprentices are supervised by shop instructors who assign the students to tasks that give them progressive training and keep a record of their work in both the classroom and the shop. Classes are held at three different hours each day, which enables employees to attend them without losing any time from the shop or making an extra trip to the plant. Approximately 1600 apprentices in tool and die rooms, electrical and heat-treating departments, and the powerhouse, and an additional 1500 employees are attending the classes.

In discussing the paper, D. F. Smith, general superintendent, General Electric Company, Erie, Pa., commented favorably upon the high caliber of the shop-instructor personnel at the Ford plant and said that this was the most important step in organizing an apprentice-training course. W. R. Mulle, American Hard Rubber Company, Butler, N. J., who also participated in the discussion, stressed the need for making apprentices motion-minded.

Mr. Simpson's paper dealt with the training of manual and white-collar workers mainly with occasional references to foremen training. For success in training adult workers, the specific aims of such training must be clearly defined and understood, the management must recognize a need for improvement, instructors must be carefully chosen, and the program must involve the least possible interference with operating routine. Some of the aims discussed in the paper were better job performance, general improvement of customer or public relations, and citizenship development.

Methods of training covered in the paper include on-the-job instruction, meetings, committee service, literature, formal educational courses, and so-called extramural activities. The discussion of practically all of these methods was supplemented by examples of their use in widely varied industries. Measurement of results and the importance of capitalizing the results of any adult-training program were also stressed.

Mr. Simpson stated that training of adults in business and industry should be viewed from a broad interpretation and not merely in the strict sense of formal, planned, and specific instruction, which should not be overemphasized because workers have made reasonable progress without it.

STATISTICAL METHODS *for* QUALITY CONTROL

By H. A. FREEMAN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE successful application in the United States of modern statistical methods to the control of the quality of industrial products has been due, in large part, to the pioneering efforts of Dr. Walter A. Shewhart of the Bell Telephone Laboratories. For a number of years previous to the publication of his treatise[1] in 1931, Dr. Shewhart was engaged in studies of the possibilities of controlling, by statistical technique, the varying quality of goods produced in mass quantities, principally telephone products; many of his progress reports, together with those of his associates, were published in the *Bell System Technical Journal* and in the *Journal of the American Statistical Association*. But it was the publication of his book, the first in the English language on the subject, that focused considerable attention on the possibilities of cost-saving industrial applications of a statistical technique which had hitherto been regarded as having academic interest alone, or at best, usefulness in the field of planned agricultural experimentation.

However, the number of industrial concerns which have actually installed a statistical quality-control program of the kind developed by Dr. Shewhart, have remained few, even after 1931. This slow rate of adoption probably can be explained, first, by a deep-seated conviction of American production engineers that their principal function is so to improve technical methods that no important quality variations remain, and that in any case, the laws of chance have no proper place among modern "scientific" production methods; second, by the difficulty of obtaining industrial statisticians who are adequately trained in this fairly complicated field. Accordingly, despite the excellent popularizing work carried out in this country during the past six years, principally by Dr. Shewhart and his associate, H. F. Dodge, with the American Society for Testing Materials, the American Standards Association, and The American Society of Mechanical Engineers as the chief collaborating agencies, probably not more than a dozen single enterprises in American mass-production industries have introduced this economical technique into their ordinary operations. The most comprehensive and successful application in this country has been made to the products of the American Telephone and Telegraph Company and its affiliated companies.

THE ENGLISH EXPERIENCE

Somewhat different has been the record of the use of this quality-control method in English industry. Following Dr. Shewhart's visit to London in 1932, English academic and industrial statisticians quickly took steps to consolidate previous progress and to facilitate the adoption of this technique by interested British industrialists. A committee was organized and Dr. Egon S. Pearson, who has remained the principal figure in this field in England, was authorized to write a practical text which would serve to develop interest on the part of English manufacturers. This tract[2] appeared in November, 1935, and constitutes the second publication to date in the English language on this subject.

An even more important step was taken in 1933, in the formation of an Industrial and Agricultural Research Section by the Royal Statistical Society. At the meetings of this Section during the past three years, a number of papers on the theory and practice of quality-control statistics have been so well presented and discussed that it seems correct to say that the supplements[3] to the Royal Statistical Journal in which these articles and discussions appear constitute the most interesting and the most thorough current literature on the subject. In these supplements, as well as in Dr. Pearson's tract, it has been convincingly demonstrated that many industrial products are produced under conditions amenable to the use of these statistical methods. Products to which these methods have already been applied by the English include coal, coke, cotton yarns, cotton textiles, woolen textiles, spectacle glass, lamps, building materials, and manufactured chemicals.

SOME ASPECTS OF QUALITY CONTROL

The application of quality-control techniques is possible because all units of a product are, in ordinary manufacture, not identical, since the cost of making all units approximately identical would in most cases be unwarranted in terms of the uses and value of the product. Variations in quality are thus conceived as economically justifiable and it is the purpose of a quality-control program to develop statistical means of showing the actual "technical" statistics of quality, the economically permissible variations in these statistics, and finally, ways and means of facilitating allocation and correction of troubles when these limits are exceeded.

In undertaking to array statistics on quality, two pertinent aspects of the field present themselves. First is the still unsatisfactorily answered related questions as to what quality really is and how specifications on quality should be set by or for consumers. For one user of ball bearings, length of life may be primary; for another, roundness is primary. A linking of two or more requisites as to quality is accordingly one problem of this technique. Secondly, these various technical specifications on quality clearly have roots in the economics of the product. These relationships between technical specifications and economic value must be more closely studied if we are to solve the problems of defining quality and setting proper specifications.

[1] "Economic Control of Quality of Manufactured Product," by Walter A. Shewhart. D. Van Nostrand & Co., New York, 1931. $6.50.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] "The Application of Statistical Methods to Industrial Standardization and Quality Control," by E. S. Pearson. British Standards Institution, London, 1935, 5s 6d.

[3] Supplements to the *Journal of the Royal Statistical Society*, London. Two supplements annually. Volume I appeared in 1933.

A second aspect is that of sampling. In most cases it is not economical to test all units; estimates regarding the quality of the total output must be made from samples of limited size along with calculations of the expected errors of these estimates. Great progress has been made in this field in the last thirty years; many relationships between samples and universes have been ascertained, and while much work is yet to be done, particularly for data which are distributed in notably skew fashion, it must be admitted that adequate distribution theory already exists. In addition to our knowledge of sample-universe relationships, we also have available, of course, the usual elementary statistical devices for describing variations in quality averages, measures of dispersion, percentage defective, etc., and with the aid of more recent work by British statisticians, we are able to decide which of these many characteristics of our distribution of data will yield us best results at minimum cost in any given case, in the economic control of quality variations.

TRAINING NECESSARY IN FIELD OF QUALITY-CONTROL STATISTICS

Workers may be trained for effective work in this field by any of three means. Self-study by engineers or other technical men in industries where the methods are applicable, is likely to provide one means; another lies in the training offered or to be offered at the colleges; the third, which the English have successfully used, is close college-plant cooperation through which promising young industrial engineers and technicians can be trained through evening courses, through leave-of-absence scholarships and through active participation in a professional society—in the English case, the Industrial and Agricultural Research Section of the Royal Statistical Society. A few remarks on these three means may be appropriate.

For those men now engaged in industrial work, self-study of this field may take either one of two courses, namely, either mastery of the foundations of the field along with the practical technique, or mastery of the practical technique alone. The author strongly urges the more difficult undertaking, for without a good understanding of the mathematical and economic background one is more likely than not to use methods where they do not apply and where they raise costs instead of lowering them, as well as to misinterpret numerical results by failing to appreciate their limitations and so on. Finally, one so casually trained will simply be unable to evaluate the literature on this subject, an undertaking which requires good mathematical and economic training. In this connection it is somewhat regrettable that neither of the two books on quality control adequately includes either the basic mathematics underlying the statistical field, or the cost-value relations which are of primary importance in determining whether or not application of the technique is economically feasible. Dr. Pearson's undertaking is admittedly of the practical, popularizing variety, permissibly void of mathematical proofs, but, unfortunately, he has given little space to that aspect of quality which one would expect a book of this type to stress, namely, the economic; Dr. Shewhart has seen fit to relegate most of the mathematical theory underlying quality control to references to basic literature often not easily available and has confined his discussion of the economic aspects of the subject to a few pages. In the light of these deficiencies, the industrial technician has a formidable task ahead, for between this literature and his customary training in elementary mathematics, economics, and statistics there lies a great gap. Perhaps the following suggestion for a beginning reading program and library will serve to illuminate the author's convictions as to the proper background:

Elementary Statistical Methods: (1) F. C. Mills, "Statistical Methods," Henry Holt & Co., New York; (2) G. U. Yule, "Introduction to the Theory of Statistics," tenth edition. G. Griffin, London; (3) A. L. Bowley, "Elements of Statistics," Part II, P. S. King & Son, London; (4) H. L. Rietz, "Mathematical Statistics," Open Court Publishing Co., Chicago.

Mathematics: (1) Any good book on elementary calculus; (2) E. B. Wilson, "Advanced Calculus," Boston; (3) A good book on probability such as by H. Levy and L. Roth, "Elements of Probability," Oxford Press, 1936.

Economics: (1) Two or more good treatises dealing with the controversial subject of value, such as those by A. Marshall, "Principles of Economics" and F. Wieser, "Natural Value;" and (2) G. C. Evans, "Mathematical Introduction to Economics," McGraw-Hill Book Company, New York.

Quality Control: (1) Articles on sampling theory by "Student," R. A. Fisher, E. S. Pearson, and their associates. These articles, written during the last thirty years, are at the basis of modern statistical technique. Their sources are listed by Dr. Shewhart; (2) Shewhart's book; (3) Pearson's book; (4) supplements to the *Journal of the Royal Statistical Society*.

In view of the difficulty and variety of the material which must be mastered by the properly qualified industrial statistician of the future, it seems proper that the universities should provide at least part of this training. At present there is a notable lack of such training opportunities. Courses in calculus and the more elementary statistical methods are generally available, but this is not true in many colleges and universities in more advanced statistics, to say nothing of the difficult, modern methods of R. A. Fisher and others; finally no university in this country, to the author's knowledge, with the exception of the Massachusetts Institute of Technology, offers a full course in Statistical Methods for Quality Control. M.I.T. will appreciate suggestions or problems which will further plant-classroom cooperation to the end of advancing the use of statistical methods for quality control in American industry.

Market Research

(*Continued from page 230*)

should indicate those individuals who specify, as frequently the same person does not do so for all lines of material.

If a campaign is to reach an industry, which of several trade papers covering it should be used? The sales-promotion manager must know reader preferences to select the publication or publications that prospects read most. Some time ago, a study of the magazine preferences of individuals who influenced the buying of electrical apparatus in three selected industries was made. Its findings enabled the proper magazine for each industry to be selected and overlapping circulation reduced to the minimum.

A catalog of one line was prompted by a market survey, which showed that even the large users commonly ordered from a catalog and seldom called in a salesman. Now, a new and improved catalog covering this line has been issued.

The advertising editor and the salesmen in the field are always eager to obtain more and better "case histories" from customers telling of advantages derived from using specific apparatus. Often, the salesman cannot spend the necessary time and effort to obtain the information needed for an effective story. Therefore, the market analyst, in connection with his interviews of prospects concerning features desired in the product, the applications, and other points, is always alert to obtain sales stories, although this may not be the major objective of the study.

ENGINEERING ACHIEVEMENTS of GEORGE WESTINGHOUSE

As Recalled by Former Associates on His Ninetieth Anniversary

THE Westinghouse Commemoration on Dec. 1, 1936, sponsored by The American Society of Mechanical Engineers as a feature of its Annual Meeting, was originated two years earlier by the Council of the Society. The Council's action followed a report by C. N. Lauer in which he said:

The engineer is on the defensive in justifying his work and establishing himself as a constructive element in civilization and a driving force in providing for the well-being of mankind.

The American Society of Mechanical Engineers has a responsibility in safeguarding the position of the engineer, and in discharging that responsibility should embrace the opportunity to dramatize the contributions of the outstanding leaders in engineering invention, design-construction, and application.

Such an opportunity occurs in 1936 in the celebration of the 90th birthday of George Westinghouse. As past-president, honorary member, and John Fritz medalist, Mr. Westinghouse has helped to establish, and is representative of, the most treasured traditions of the A.S.M.E. It is fitting, therefore, that this Society should grasp the opportunity to make plain to the public the far-reaching results of the work of this great engineer on the occasion of the 90th anniversary of his birth.

The committee in charge comprised Roy V. Wright, chairman, S. W. Dudley, James H. McGraw, Charles F. Scott, R. I. Rees, Ely C. Hutchinson, J. B. Wright, and W. G. Marshall. The committee desired a more intimate and personal portrayal of the man than is usual in conventional biographies and a presentation of his achievements not only as things accomplished but in their historical perspective. It delegated Mr. Scott, who entered the Westinghouse Electric Company in 1888, to collect anecdotes and reminiscences and appraisals from associates of Westinghouse who could speak from personal knowledge. Selections from this material formed the basis of a unique presentation of the engineering achievements of Westinghouse. These were worked into a "continuity" in which nearly a score of those who knew his work—most of them long-time associates—told what he did and how he did it. In the presentation the participants were seated in a semicircle on the platform and appeared in the following order:

Prologue, "Westinghouse in Perspective," Mr. Batt.

I "The Air Brake," Messrs. Budd, Nichols, Swasey, and Campbell.

II "Alternating Current," Messrs. Berresford, Stillwell, Scott, and Beardsley.

III "The Steam Turbine," Messrs. Keller, Hodgkinson, and Smith.

IV "Railway Electrification," Messrs. Storer, Vauclain, Gibbs, Murray, and Duer.

V "Industrial Relations," Mr. Miller.

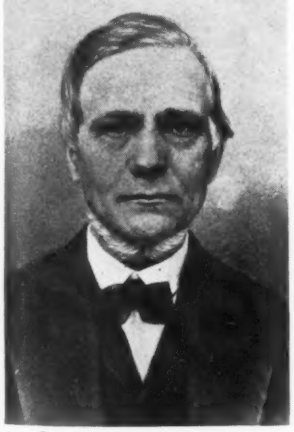
Epilogue, Mr. Scott.

Supplementing the foregoing program were two addresses presented in the evening by President Angell, of Yale University, and Paul D. Cravath. These addresses appear in MECHANICAL ENGINEERING for March, 1937.

WESTINGHOUSE IN PERSPECTIVE

BY W. L. BATT

PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 1936



FATHER

WE ARE gathered to celebrate the ninetieth anniversary of the birth of George Westinghouse by recounting his career and achievements. Westinghouse exemplifies the "rugged individualism" of the pioneers who built the America we inherit. He did not invade the wilds of the West but was a pioneer on the new social frontier where applied science and engineering and industry bend the forces of Nature to the practical welfare of the people.

Transportation and power—two great agencies in the industrial, economic, and social changes of recent times—were his chosen fields. To them, he contributed new methods and mechanisms. He made the inventions of Watt and Stephenson and Faraday vastly more effective by extending their fields of operation and useful service.

Not merely an inventor or technical expert, he was an engineer in the broadest sense. To make Nature's elements of use to mankind involves the recognition of a need or an opportunity, the invention of some new method or device, and the de-

MOTHER

GEORGE WESTINGHOUSE BRIDGE, LINCOLN HIGHWAY, EAST PITTSBURGH

velopment of the idea into concrete and practical form; then preparing for its production, convincing others of its usefulness, and supplying it for service. All these things Westinghouse did. He had facility in dealing with men and organizing them for research and development and manufacturing as well as facility in dealing with physical things, a rare combination of the complementary qualities of the two men who made the firm of Bolton and Watt successful in launching the steam engine.

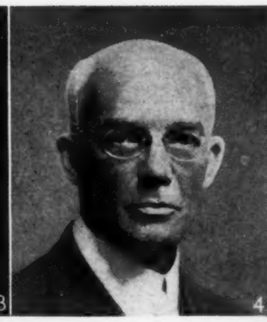
Westinghouse was a self-made man. He had a grand inheritance—physical, intellectual, moral. His liking for making new things was stabilized by routine work in his father's factory for manufacturing agricultural machinery. Hands and head worked together. The engineering of his day was empirical. He developed his own ideas of engines and mechanisms and made them himself before the days of schools with engineering laboratories. Air pressure and its control by valves became matters of intuition. He was alert, ingenious, capable, ambitious. In his advance from a boy working at the bench to the head of great industries, he acquired experience in every stage of industry, and he knew the workmen as his fellow workers.

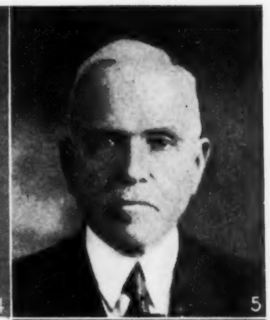
When he entered young manhood, the environment also was propitious as the stage was then set for a stirring act in the drama of transportation and power. The expansion following the Civil War created new demands with alluring opportunities; the railroads with forty years of pioneering experience and century-old steam power, now giving new impetus to industry, were the beginnings on which to build.

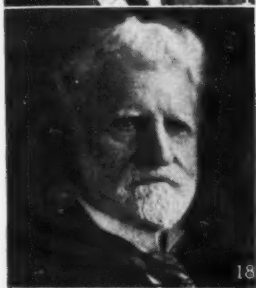
To his heritage and environment, he brought the dynamic power of a great personality. The last third of the nineteenth century was a period of phenomenal development in transportation and power and in industry as the little shop became the great corporation. And in those decades of engineering and industrial pioneering which made possible the enormous expansion that has been experienced since the turn of the century, Westinghouse was a leading actor.

He was acclaimed by his fellow engineers. The American Society of Mechanical Engineers made him its President and Honorary Member. The American Institute of Electrical Engineers awarded him the Edison Medal; the United Engineering Societies, the John Fritz Medal; the German engineers made him the first American recipient of the Grashof Medal. He had other medals and honors and degrees, American and foreign, but he was introduced to the International Railway Congress as its president in these words as "one who needs neither prefix nor affix to his name, George Westinghouse."

The evening addresses will deal with Westinghouse, the man, and with the enduring influence of his career on human progress. This afternoon, his engineering achievements will be reviewed by a group of men who are familiar with his work, many of whom were his associates. I ask Prof. C. F. Scott, who arranged this presentation, to act as the Leader. Professor Scott







Taking Part in 90th Anniversary of George Westinghouse (1846-1914)

1 **Chas. F. Scott**
Yale University, formerly with Westinghouse Electric & Manufacturing Co., *Leader*

2 **W. L. Batt**
President (1936), A.S.M.E., *Chairman*

3 **Ralph Budd**
President, Burlington Lines

4 **W. W. Nichols**
Assistant to Chairman, Allis-Chalmers Manufacturing Company

5 **Thomas Campbell**
Oldest Employee, Westinghouse Airbrake Company

6 **A. W. Berresford**
Past-President, A.I.E.E.

7 **L. B. Stillwell**
Consulting Electrical Engineer, formerly with Westinghouse Electric & Manufacturing Co.

8 **C. R. Beardsley**
Superintendent of Distribution, Brooklyn Edison Co.

9 **E. E. Keller**
Formerly Vice-President, Westinghouse Machine Co.

10 **Francis Hodgkinson**
Consulting Engineer (retired), Westinghouse Electric & Manufacturing Co.

11 **Frank W. Smith**
President, Consolidated Edison Company

12 **N. W. Storer**
Consulting Engineer (retired), Westinghouse Electric & Manufacturing Co.

13 **S. M. Vauclain**
Chairman, Baldwin Locomotive Works

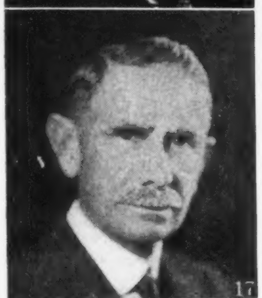
14 **George Gibbs**
Of Gibbs and Hill, Consulting Engineers

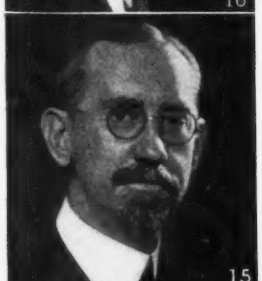
15 **W. S. Murray**
Consulting Engineer, formerly with the New Haven Railroad

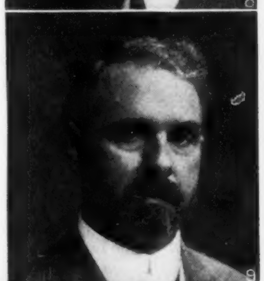
16 **J. V. B. Duer**
Chief Electrical Engineer, Pennsylvania Railroad

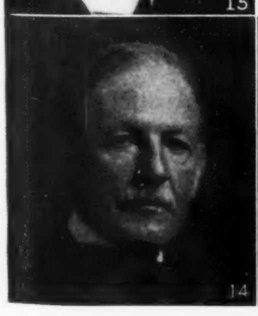
17 **John F. Miller**
Vice-Chairman, Westinghouse Airbrake Company

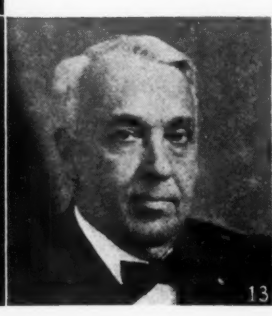
18 **Ambrose Swasey**
Past-President, A.S.M.E.

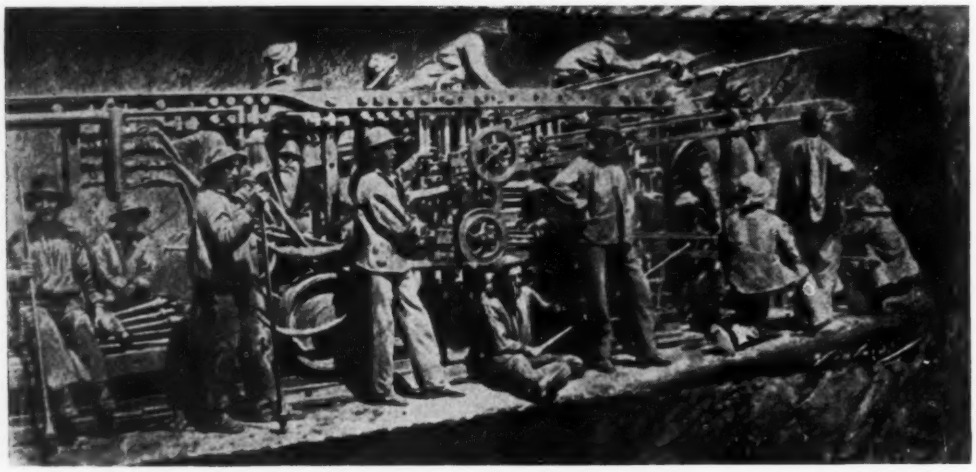












THE INSPIRATION OF THE AIR BRAKE—PRINT OF MONT CENIS TUNNEL, AIR DRILLING

I THE AIR BRAKE

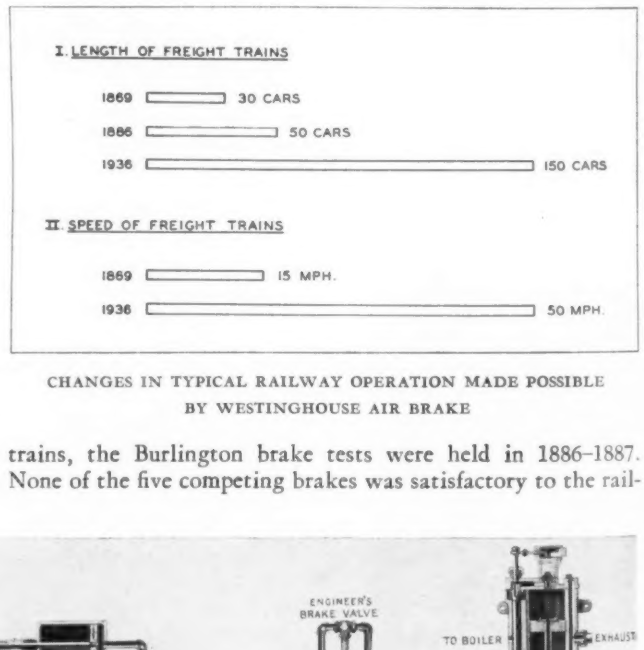
C. F. SCOTT (THE LEADER): In recounting the achievements of George Westinghouse, we can tell of only a few of his activities; he had many others; his patents numbered nearly 400, and he organized three score companies. Progress in science and engineering halts at times as some limit is reached. Then, perchance, a new discovery or invention brings release, and a new era develops. Thus, in the '60s, the bessemer-steel rail and a standard track gage and the joining of short roads into great systems portended a new era in transportation. But it was halted—safety at higher speed demanded an adequate brake. There was none. Progress awaited something new—it was a crisis. Fortunately we have Ralph Budd, president of the Burlington which figures in the Westinghouse story, who can tell us of the railroads and what they owe to Westinghouse. Mr. Budd.

RALPH BUDD: This audience knows our dependence upon railroads. They have developed and unified America on a scale impossible by oxcarts and stagecoaches and canal boats. Industries rely upon railroads for transportation of raw materials and for distributing their products, while the public receives its winter's coal and its daily bread in freight cars.

The problem in the early days was to make locomotives powerful enough to pull trains; at first there were but few cars in each train. As they became longer and speeds greater, the problem was to stop the trains. Older men here today recall the whistle for "down brakes." Brakemen ran along the tops of freight cars, tightening brake wheels with pick handles as they passed from one car to another. They rushed through passenger coaches, turning the brake wheels on the open platforms, and, even then, the train often ran too far and had to back to the station.

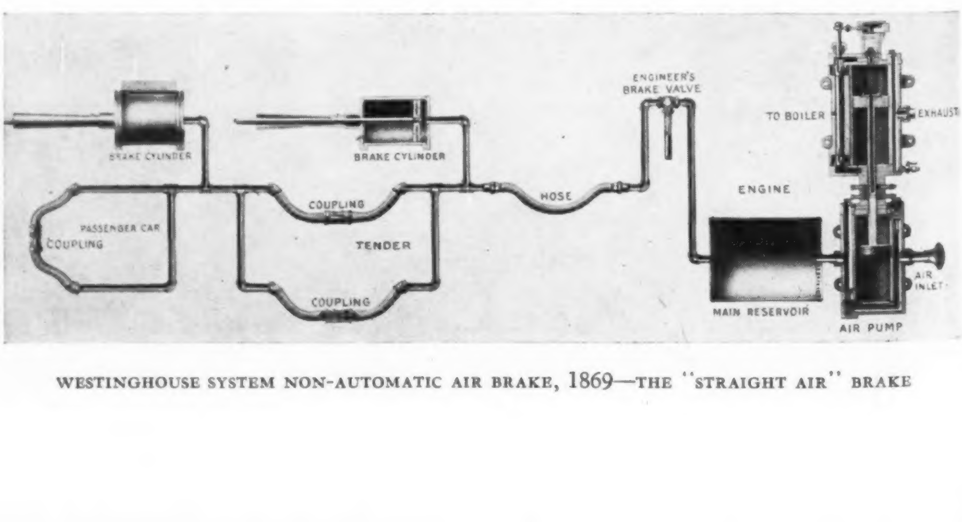
Young Westinghouse saw the results of a collision that prompt braking would have prevented. He realized that the method of application was inadequate; brakes on all the cars should be operated at once and by the engineer on the locomotive, but how? He considered buffer and chain-operated brakes and a steam pipe to cylinders under each car but found no good answer to his cumulative problem. An attractive girl sold him a magazine; it told of compressed air driving rock drills in constructing Mont Cenis tunnel. In this, he saw the solution for his problem. Many difficulties were overcome, but, finally, the Steubenville Accommodation out of Pittsburgh in April, 1869, a year notable in railroad annals, had gone but a few hundred yards when an emergency stop prevented a crossing accident and dramatically acclaimed the merit of the air brake. Here was the result of three years of effort, and it was the beginning of decades of development to adapt the brake to longer trains and higher speeds. Without the improved brake, high-speed trains, as we know them, would be impracticable, indeed railroading as it is today would be impossible. Over 600 patents on brakes had been taken out when Westinghouse entered the field; he climaxed them all, and the principles which he developed have not been superseded.

Looking to the introduction of continuous brakes on freight

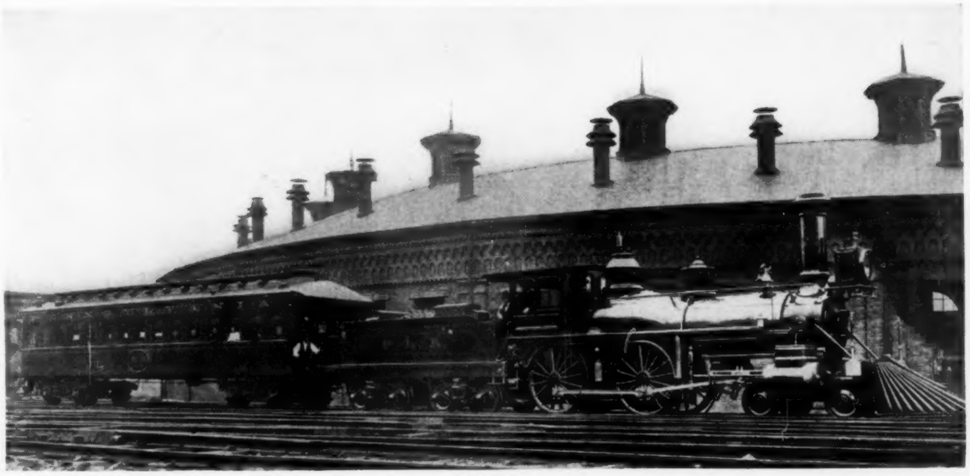


CHANGES IN TYPICAL RAILWAY OPERATION MADE POSSIBLE BY WESTINGHOUSE AIR BRAKE

trains, the Burlington brake tests were held in 1886–1887. None of the five competing brakes was satisfactory to the rail-



WESTINGHOUSE SYSTEM NON-AUTOMATIC AIR BRAKE, 1869—THE "STRAIGHT AIR" BRAKE



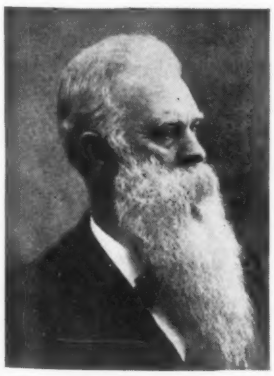
FIRST LOCOMOTIVE EQUIPPED BY WESTINGHOUSE WITH COMPRESSED AIR POWER BRAKES FOR REGULAR ROAD SERVICE

roads. The Westinghouse brake sufficed in service work but emergency applications produced shocks due to slow serial action. It was a crisis. A man who was there and had a part in the undertaking is here this afternoon. Let us ask him to tell the story. Mr. Nichols.

W. W. Nichols: In the 1887 competitive air-brake tests, under the auspices of the Master Car Builders Association, following the defeat of Westinghouse by the Carpenter brake of Germany, "G. W." suddenly appeared on the scene to the relief of the distraught Westinghouse Air Brake officials whose agitation resolved itself into a sweet tranquillity. Indeed, one high executive observed to me, "Now that Mr. Westinghouse is here, everything will come right."

The trials had been at the West Burlington hill on the main line, and, as an engineer of tests, I had charge of the dynamometer car. Following the formal trials, Mr. Westinghouse instituted a private series of tests under M.C.B. conditions, and he spent much time during experimental runs studying the records and discussing, with me, their implications. Finally, one morning, he left impetuously before noon, inviting me to join him at lunch in his private car on the West Burlington Shops' siding. Later, as I passed through the corridor to the dining room, he emerged from his stateroom and waved a bit of brown paper, exclaiming with characteristic enthusiasm, "Here's the triple that will revolutionize railroading!" How true that proved.

He hurried to the telegraph office and wired the factory preliminary specifications with orders to rush 50 triples, mailing his rude sketch to clarify his instructions. According to my recollection, the first test of the new triples proved a complete confirmation of his judgment, for the 50-car freight train, running on the level at 20 mph, stopped in 98 ft, surprisingly without shock, both records without precedent. This contradicted the conclusions of the brake trials committee that "the best type of brake for freight service was one operated by air, *in which the valves were actuated by electricity*." But electricity, highly objectionable in such a service for many obvious reasons, he excluded in his new design, in whose application, as already remarked, "G. W." evidently visualized an amazing advance in train operation, since literally attained as every one knows.



DANIEL TATE
(Engineer on locomotive hauling first regular train equipped with air brakes.)

Now, above all, the noteworthy event lay in "G. W.'s" returning home *before* a test of this triple; his sublime confidence in his inventive foresight made his presence at any trial utterly superfluous. As I wrote Colonel Prout, his biographer, a few years ago, "This was one of the most dramatic incidents of my career." No wonder the Colonel in his acknowledgment avowed that

It was so like "G. W." As long as I live, I shall regret that I did not understand G. W's. soul while he was alive. I had to grow up to that understanding and that took quiet thought and time was an element.

Mr. Budd: Mr. Nichols, we are indebted to you for this firsthand account of how a major improvement in the braking art was achieved. Now, I have the unique privilege of presenting a letter from a dear and longtime friend of George Westinghouse whom the Society also honors on this, his own ninetieth anniversary, our beloved Ambrose Swasey.

Cleveland, Ohio
Nov. 19, 1936

Dear Professor Scott:

I wish it were possible for me to speak at the Westinghouse Ninetieth Anniversary celebration, but it seems best that I should not attempt to do so.

On my return from a trip around the world in 1910, I said to Mr. Westinghouse:

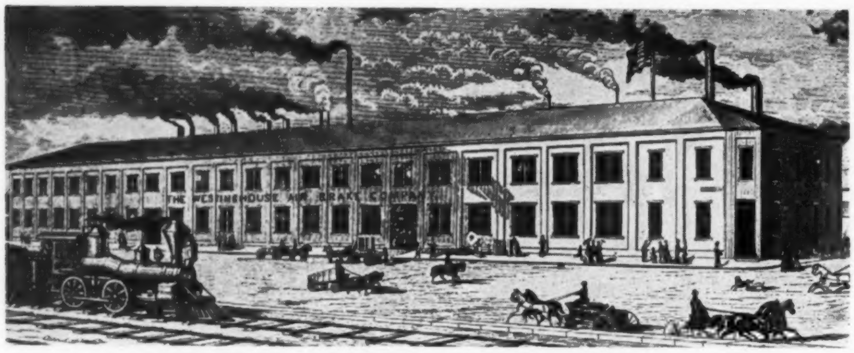
> When Mrs. Swasey and I were leaving Peking for Hankow, as we sat in the car, we heard the swish of the air under the car, and Mrs. Swasey asked what that meant. I said to her that the Chinese railroad men were testing the Westinghouse air brakes in order to see that they were in good condition before we started on our long journey across China.
>
> And so, not only in China, but also in Japan, in Burma, in India, in Egypt, in Europe, and back to America, your air brakes were in use, and no one can estimate the prevention of destruction of equipment and the saving of life brought about by your wonderful invention, the air brake.

I certainly hope that someone will tell about the triple valve, that marvelous mechanism on which Mr. Westinghouse worked for many years. As our company made machines and tools for the manufacture of these valves, I was, of course, deeply interested in it. As the railroad was only 300 or 400 ft from the old homestead where I lived as a boy, I remember so well the brakemen on the freight trains running from one car to the next to set the brakes as the trains went down a considerable grade in front of the house. This was counted as one of the most dangerous occupations in which men were engaged.

On going back to the old homestead in recent summers, I have taken particular notice of the trains of a hundred or more cars being stopped almost instantly by the same little triple valve. I am confident some one can tell a wonderful story regarding Mr. Westinghouse's genius in the development of this little mechanism.

With all good wishes, I am

Most sincerely yours,
Ambrose Swasey



LIBERTY STREET AT 24TH AND 25TH STREETS, PITTSBURGH

Mr. Swasey's experience reminds me of seeing this same old friend from home, the Westinghouse air brake, on passenger trains in various parts of Russia. There, because the letter B takes the place of V and W, it is Bestinghouse, a modification that is complimentary to say the least.

Such is the story of a boy that a collision set to thinking; following the air brake, he developed air-operated railroad switches and automatic signals. Then came the friction draft gear for absorbing the blow of one car on another when starting and stopping, companion of the air brake in operating advancement; and later came railroad electrification. These are contributions of Westinghouse to safety, speed, and economy in transportation; they make him a benefactor of mankind.

THE LEADER: One of the veterans of the Air Brake Company, Thomas Campbell, is here, and I want to ask him some questions regarding the early days. Mr. Campbell, what was the first thing you had to do with the air brake?

THOMAS CAMPBELL: The first equipment for the air brake was made by Atwood and McCaffrey, where I was learning my trade. I helped to make the first castings for the valves and a few years later, in 1871, went to the 25th Street shop of the Air Brake Company.

THE LEADER: Why did you change?

MR. CAMPBELL: Why? Because at that time a man was considered lucky to get a job with the Westinghouse Company. Mr. Westinghouse inaugurated the piecework system and gave the men to understand through the superintendent, that the more money they made, the more the company made; $2.50 per day was good wages in other shops, while the men in the air-brake shops on piecework averaged $4 per day.

THE LEADER: What about shop equipment?

MR. CAMPBELL: Our shop had up-to-date tools; it had gear lathes, the first I ever saw; molding machines from Scotland were introduced in the foundry and were improved.

THE LEADER: How did he treat the men?

MR. CAMPBELL: He gave us all a dinner at the old Union Station Hotel. The men themselves have continued these dinners, and I have attended all of them. For many years, he gave us all a turkey at Thanksgiving. He chartered a train and took us all to the Centennial at Philadelphia for a week in 1876. In 1881, the shops were moved to Allegheny, where washrooms and lockers were introduced so that we could come to the shop and leave in good clothes. He introduced the Saturday half holiday which we appreciated because there was a base ball field nearby.

THE LEADER: Are you still working for the Company?

MR. CAMPBELL: No. Aftermore than fifty years of service, I retired. I am the oldest living Westinghouse employee. When they designed the Westinghouse Memorial in Schenley Park, I was the model to represent the mechanic; I hold a hammer and am proud of it. Since I retired, I have been receiving a monthly pension and am living comfortably with my son.

THE LEADER: Mr. Campbell, I think you told me that the Anderson boy, where Mr. Westinghouse boarded, used to invite you over as you were both musicians. What kind of music did Mr. Westinghouse like?

MR. CAMPBELL: He especially enjoyed the Scotch and Irish airs, the lively ones.

THE LEADER: Can't you give us a sample?

MR. CAMPBELL: I will be pleased to try.

[Mr. Campbell then took from his pocket a piccolo and played the Irish air, "Haste to the Wedding." As an encore he gave the Scotch air, "Money Musk."]

II ALTERNATING CURRENT

THE LEADER: And now, we turn to electric power. Professor Elihu Thomson told me that, at the Centennial in 1876, he was thrilled by a dynamo operating one arc lamp. Thus, the steam engine could now produce light as well as power and deliver it far beyond the reach of shafts and belts. A decade later, there were commercial lamps and motors, but the distance by the prevalent Edison three-wire system was limited to a few thousand feet. Westinghouse, after establishing the air brake, took up railroad signals and natural gas and established new industries. He investigated electric lighting. He secured Stanley and Shallenberger as experts and manufactured dynamos and lamps in a small way. He saw a great future if transmission distances could be extended. Then, he read of transmission by high-voltage alternating current in Europe. The transformer seemed analogous to his reducing valve for high-pressure natural gas. He acted at once and made the year 1886 significant in the history of electric power. I introduce the chairman of the committee which commemorated the event, A. W. Berresford.

A. W. BERRESFORD: The fiftieth anniversary of alternating current in America was celebrated on the twentieth of last March. Meetings of the American Institute of Electrical Engineers which were conducted simultaneously in nearly fifty cities recounted how Westinghouse brought the Gaulard and Gibbs system to America, how it was modified, and then given practical demonstration by

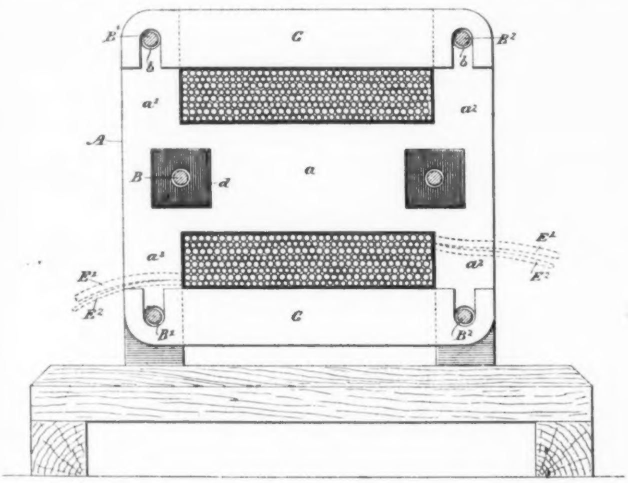
GAULARD AND GIBBS TRANSFORMER

Stanley at Great Barrington, and what has happened since.

But in Pittsburgh and Hartford, the March floods canceled the meetings; meeting places were waterlogged; power stations were submerged; electric service ceased. Night brought darkness. Nearly everything stopped; streetcars, elevators, newspaper presses, and electric pumps in city water works and in gasoline filling stations. Domestic appliances were inert; refrigerators, irons, doorbells, radios, clocks, and electrically controlled furnaces. Industries were at a standstill. Communication systems lost their operating current. It was tragic but, as only a major catastrophe can, it demonstrated the completeness of our present-day dependence on electric power as developed from the simple beginnings of a half-century ago.

The Leader: Just before the commercial installation of alternating current, L. B. Stillwell, a young college graduate, aided in preliminary tests. He became an important member of the technical staff in the eventful decade of engineering development that followed. Of this, he will tell us. Mr. Stillwell.

L. B. Stillwell: I have been invited to sketch in a very few minutes the work of George Westinghouse in the electric field in the decade preceding November, 1896, when polyphase alternating current from Niagara Falls was first delivered in



WESTINGHOUSE TRANSFORMER (1886 PATENT DRAWING)

Buffalo. In the time allotted, I can touch only some of the high spots of that progressive development which he directed with such masterful grasp and energy.

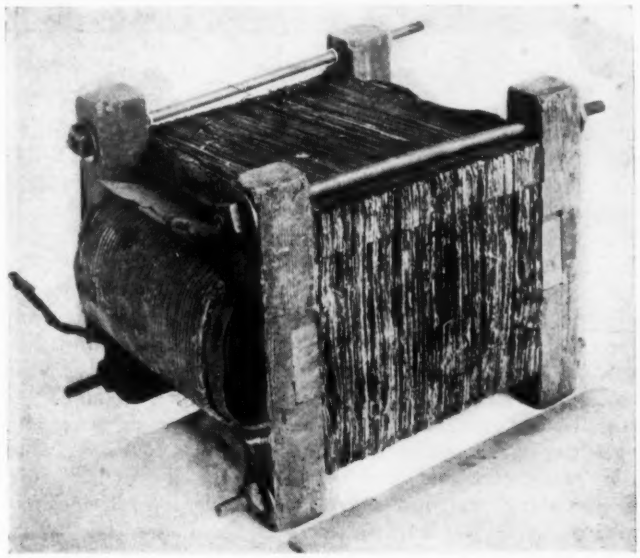
Mr. Westinghouse's great contribution to electric power lay in his early vision of its possibilities and his aggressive leadership in the development of alternating-current apparatus for realizing them. He was not an electrical expert. Nevertheless, in less than three weeks from the time he first saw a transformer, he made an outstanding contribution as an inventor. His mechanical design of the modern transformer is summarized by Reginald Belfield, who brought the Gaulard and Gibbs apparatus to America, in the following words:

> Mr. Westinghouse applied himself toward the production of a piece of apparatus which could be wound on a lathe, utterly discarding the unpractical soldered joints and stamped copper disks for the more commercial form of ordinary insulated copper wire. It took Mr. Westinghouse only a few days to design an apparatus which has been the standard ever since.

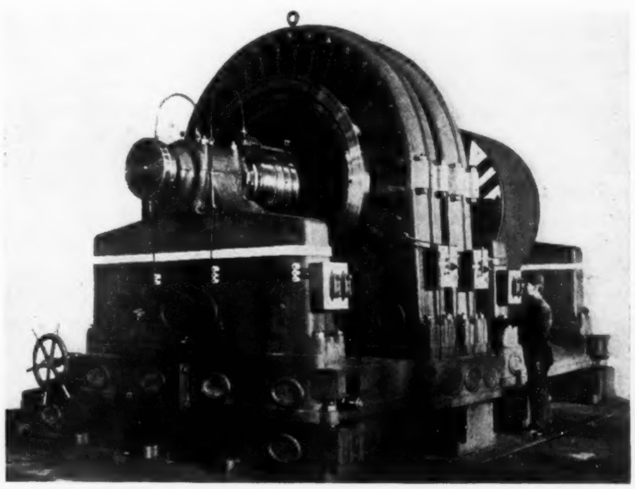
This design was patented in 1886; it was soon followed by his patent on the oil-insulated transformer. It is a fact of peculiar interest to mechanical engineers that the problem of "turning the Gaulard transformer inside out" was solved with wonderful promptness by a great mechanician having at that time but little knowledge of the electrical factors involved.

The first commercial alternating-current plant at Buffalo began operation fifty years ago last Thursday. This was quickly followed by many similar plants in other cities.

Keen competition from the company manufacturing Edison apparatus, already in use, was at once encountered. Serious efforts were made in several states to secure legislation prohibit-



TRANSFORMER WITH WESTINGHOUSE H-PLATES AND LATHE-WOUND COILS



750-KW ALTERNATOR—WORLD'S FAIR

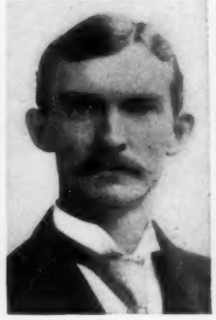
ing line voltages exceeding 800 volts. Westinghouse opposed this move with his usual energy, and it did not succeed.

For Westinghouse and his staff at Pittsburgh, the technical problems were many. There was no alternating-current meter, no motor, and no arc lamp. Larger and more reliable generators, larger transformers, improved switches, lightning arresters, and incandescent lamps were needed. Stanley, at Great Barrington and Shallenberger, Schmid, Belfield, and Lang at Pittsburgh worked with utmost energy, and the technical staff was

REGINALD BELFIELD

WILLIAM STANLEY

ALBERT SCHMID



O. B. SHALLENBERGER

PHILIP LANG

NIKOLA TESLA

increased gradually by employing young college graduates. Of these, seven have served since that time as President of the American Institute of Electrical Engineers. Mr. Byllesby once told me that when Westinghouse authorized him to increase the staff, he said: "There is but one rule that I must insist upon. I want you to employ none but gentlemen."

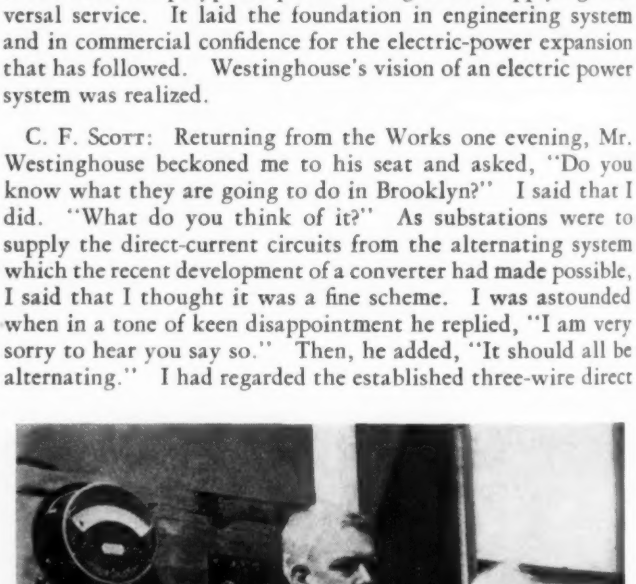
Westinghouse spent much time in the shop and laboratory of the Electric Company. A new device challenged his lively interest. His mental grasp was quick and definite and his suggestions, even on purely electrical problems, were to the point and often fruitful. His attitude was encouraging and highly stimulating. Rarely did he lose patience even when his ideas were strongly opposed. When he occasionally expressed himself more emphatically than necessary, it was his habit, within a day or two, to make sure that cordial relations had been restored. While his temperament was masterful, he was habitually courteous.

In 1888, came Shallenberger's brilliant invention of the induction meter. In the same year, Nikola Tesla was granted his United States patents covering the polyphase motor and system. Westinghouse promptly secured the American rights. Tesla came to Pittsburgh to develop his motor. He made vain attempts to adapt it to the existing single-phase, 133-cycle circuits. The polyphase power system and the obvious advantages of direct connection of engines and generators called for a lower frequency. In 1890, the Company's engineers made a careful study to determine the frequency most suitable. Two frequencies were selected as standard, namely, 60 cycles for general use and 30 cycles for conversion into direct current.

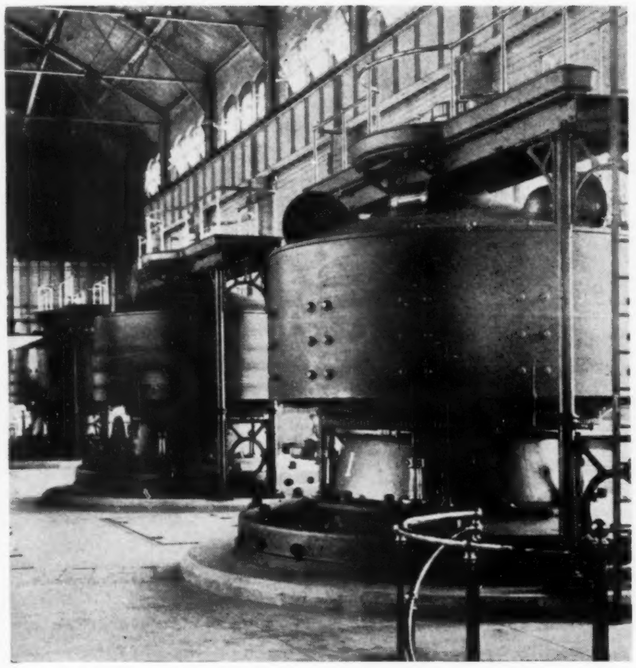
In 1890, E. D. Adams, president of the Cataract Construction Company, and his chief engineer, Dr. Coleman Sellers, were in London. By invitation, Mr. Belfield and I discussed with them the problem of utilizing Niagara Falls' power. Mr. Adams organized a competition for the best solution of the problem. Cash prizes were offered. Anticipating the success of the Tesla motor, I urged the American Westinghouse Electric Company to submit plans. Mr. Westinghouse disapproved and later explained: "These people are trying to secure $100,000 worth of information for $3000. When they are ready to do business, we will submit our plans." The competition produced plans for transmitting power by compressed air and other nonelectrical means, also several electrical projects, nearly all for direct current.

Niagara presented an extraordinary opportunity to launch the polyphase system. It all seems obvious now, but, at that time, even Lord Kelvin, president of the Niagara Commission, which Mr. Adams organized, strongly opposed alternating current. The great need was a convincing demonstration. Westinghouse provided it. His bold adventure at the Chicago World's Fair in 1893 is a well-known story; apparatus not yet designed was essential; a patent injunction against the use of the "all-glass-globe" incandescent lamp was met by the stopper lamp. The result was a convincing demonstration of the polyphase system. As the Fair closed, a contract was executed for three two-phase alternators of "5000 electrical horsepower." The plant began operation in 1895, and, in November, 1896, Niagara power was transmitted to Buffalo. Lord Kelvin approved. A decade of electrical pioneering and development, beginning with the little single-phase lighting plant of 1886, ended with the polyphase plant at Niagara for supplying universal service. It laid the foundation in engineering system and in commercial confidence for the electric-power expansion that has followed. Westinghouse's vision of an electric power system was realized.

C. F. SCOTT: Returning from the Works one evening, Mr. Westinghouse beckoned me to his seat and asked, "Do you know what they are going to do in Brooklyn?" I said that I did. "What do you think of it?" As substations were to supply the direct-current circuits from the alternating system which the recent development of a converter had made possible, I said that I thought it was a fine scheme. I was astounded when in a tone of keen disappointment he replied, "I am very sorry to hear you say so." Then, he added, "It should all be alternating." I had regarded the established three-wire direct



GEORGE WESTINGHOUSE AND LORD KELVIN



FIRST THREE 5000-HP ALTERNATORS AT NIAGARA FALLS, 1895

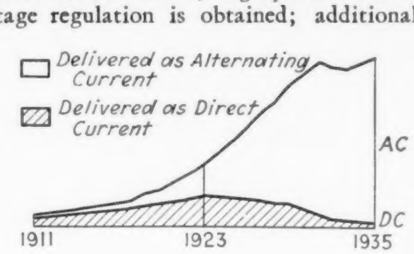
current in cities as permanent. The sequel will be told by C. R. Beardsley, an engineer with the Brooklyn Edison Company. Mr. Beardsley.

C. R. Beardsley: The invitation to participate in this commemorative meeting honoring Mr. Westinghouse is very much appreciated. The establishment of a unified alternating-current distribution system is another fulfillment of his keen vision. The Brooklyn Edison Company began about 15 years ago to replace its direct-current low-voltage distribution by alternating current. Direct-current substation capacity for a coincident peak load of about 80,000 kw and the corresponding circuits were to be discarded and replaced by an alternating-current network. The network, in turn, was to be extended outward to displace the alternating-current radial feeds as the density of load warranted the change.

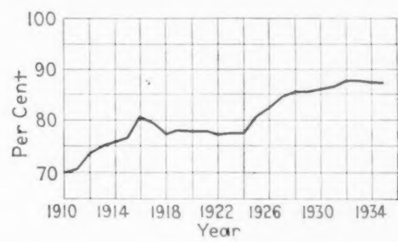
In addition to this large capital expense for network, there was the problem of changing consumers' services, meters, and utilization equipment, that is, direct-current motors and a large variety of direct-current devices which do not operate on alternating current. Some 130,000 customers were served on direct-current circuits. The problems of surveying these premises, making new wiring layouts, and specifying the alternating-current equipment, and then satisfying consumers and obtaining permission to make the change were of huge proportions.

The changeover is virtually complete with approximately 225 customers now being served on direct-current lines. These are, however, some of the very large installations and most expensive to change. Completion is now in sight. As a result of this very considerable accomplishment, we have found that the prediction of advantages was well founded. Two thirds of the distribution losses have been saved; highly reliable service with better voltage regulation is obtained; additional

ELECTRICAL ENERGY IN BROOKLYN



EFFICIENCY OF BROOKLYN SYSTEM



capacity can be readily provided with the minimum of street operations involving tearing-up and repaving.

Thus, Brooklyn has been a large-scale pioneer in the shift to alternating current, first by interposing rotary-converter substations and now by doing away with direct current altogether. Nearly all the large cities are displacing direct-current service as the economic conditions warrant. Philadelphia has virtually completed the program. Detroit is making progress. Chicago is starting. Brooklyn was, however, one of the first to reach virtual completion and is thoroughly satisfied with the results. Thus, actual accomplishment proves the far-sighted wisdom of Mr. Westinghouse's vision, to which Mr. Scott referred.

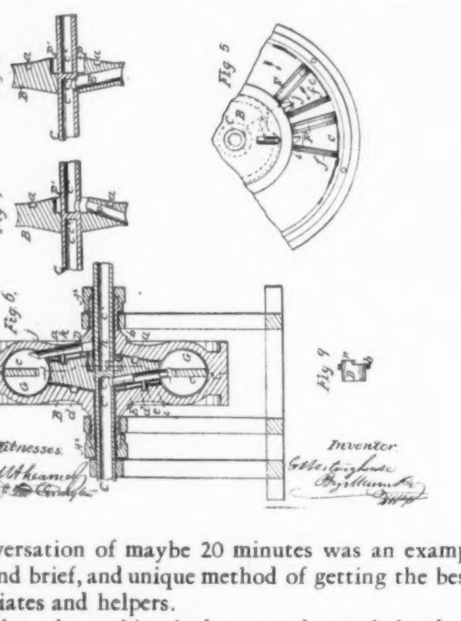
III THE STEAM TURBINE

The Leader: Electric power made new demands upon the steam engine. The old-time engine drove the machinery of a single mill; but an electric power station can send power to many mills and elsewhere.

Westinghouse became interested in making a new kind of engine long before there were any dynamos to be driven. By good fortune, his experiments prepared him to meet the new demands of electric power later on. E. E. Keller, Westinghouse manager at the Chicago Fair in 1893, became vice-president of the Westinghouse Machine Company that built steam and gas engines. He is unable to be present but sends a contribution which tells how Westinghouse acquired the turbine.

E. E. Keller: The old steam engine driving his father's shop awakened the interest of young George Westinghouse. But why have a reciprocating engine to turn a shaft? He made a rotary engine and his first patent was for it and was issued before he was twenty. The rotary engine continued to be his hobby, and, in the '80s, he visioned an engine of high speed to avoid belts and to develop lower-cost electric generators. He redoubled his efforts, but, while his experimental rotaries awakened alluring hopes, they persisted in taking too much steam.

In 1895, he learned of a rotary engine working on the turbine principle. Its construction was unknown to us and became a subject for dinner-table discussion. A letter of inquiry brought a prompt response from Parsons. Westinghouse handed it to me, saying, "I wish you would go over to England and find out whether we ought to have this and if so, get it." On my asking his idea of its value, he replied, "I have not thought about price. I leave it entirely to your judgment. Only don't let it get away from us if it has merit. It is all up to you now. When can you sail?"



This conversation of maybe 20 minutes was an example of his direct, and brief, and unique method of getting the best out of his associates and helpers.

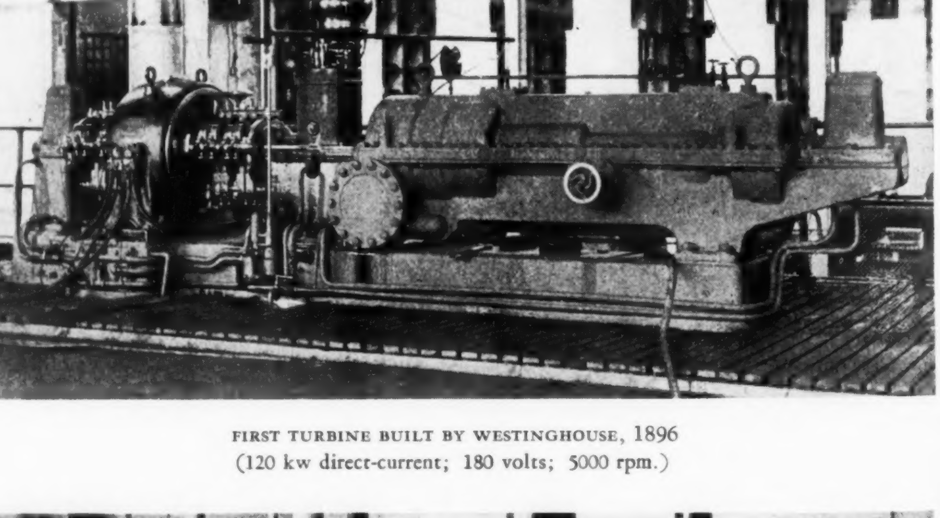
I found that the turbine had not made much headway in general favor or in commercial application, but it seemed full of possibilities and promise, so I secured it. None of us fully realized then that this agreement was the death knell not only of Westinghouse's own rotary hobby but also of the large reciprocating steam engine. It was an outstanding example of Westinghouse's far-sighted vision of future needs and his indomitable courage in pioneering in new fields.

I not only secured the turbine but, with greater difficulty, also acquired an engineer. Both have had a profound influence upon the development of power. The engineer is here and will now tell the story of the turbine. Mr. Francis Hodgkinson.

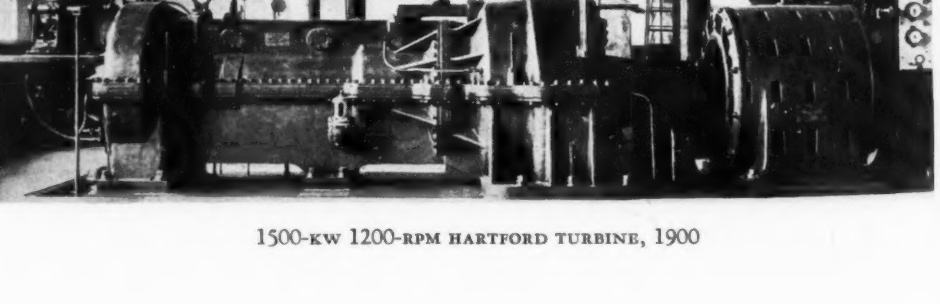
FRANCIS HODGKINSON: Mr. Keller stated that the Parsons steam turbine had not been generally accepted in England when, in 1895, the interest of Mr. Westinghouse was aroused. Parsons began his activity in 1884, and it would seem that if his turbine had merit, it should have established itself within 11 years. Difficulties, not of an engineering character, however, had arisen; his partners had not the vision to go beyond the market for small electric generating sets principally for shipboard use. A dissolution of partnership ensued, in which Parsons lost the rights under his original patents, regaining them only a year before Mr. Keller appeared. Mr. Westinghouse's interest was excited by his vision of the possibilities of the steam turbine rather than by the success achieved on the part of Parsons.

The turbine of 1895 was confronted by many problems of technical detail, but a greater obstacle was the prevalent skepticism toward this high-speed innovation that depended upon jets of steam being directed, windmill fashion, against buckets, instead of expanding behind a comparatively leakless piston. This skepticism required the vision, courage, perseverance, and diplomacy of a George Westinghouse to overcome. He at once proceeded with the building of experimental machines, and, in 1898, he successfully undertook to demonstrate their sufficiency and reliability by making the plant of the Westinghouse Air Brake Company dependent upon them. The small steam engines that were distributed throughout the factory for driving line shafting were discarded and replaced by electric motors. Wires were substituted for steam pipes. The new power station was equipped with three 300-kw Westinghouse-Parsons turbine generators. Mr. Westinghouse had spent some thirty years in endeavoring to develop a successful form of rotary engine. The turbine made his dreams come true.

One year later, Mr. Westinghouse undertook the construction of a 1500-kw 1200-rpm unit, introducing some radical features of design, notably shortening the machine by tucking bearings, glands, and other parts within the turbine rotor. Mr.



FIRST TURBINE BUILT BY WESTINGHOUSE, 1896
(120 kw direct-current; 180 volts; 5000 rpm.)



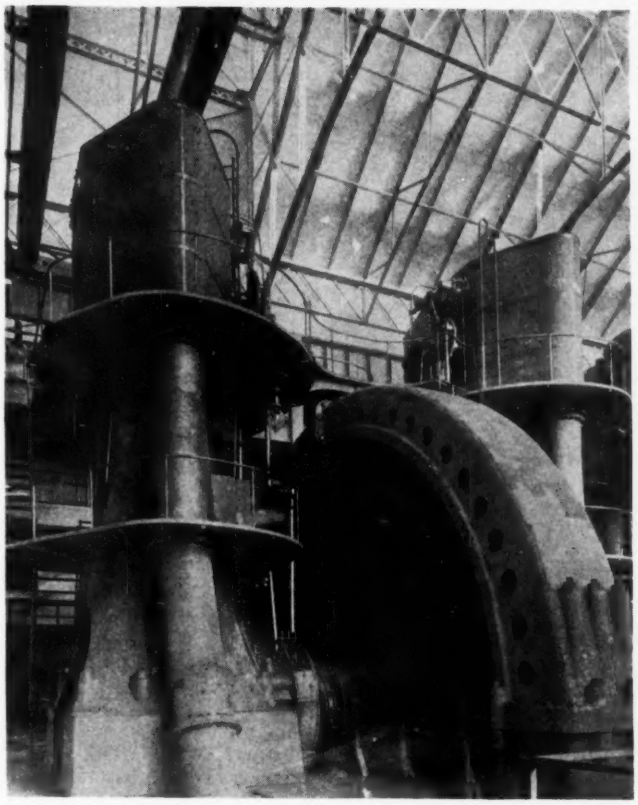
1500-KW 1200-RPM HARTFORD TURBINE, 1900

Dunham heard of it before completion; he visited the works and purchased it for the Hartford Electric Light Company, of which he was president. Mr. Dunham was famous for courage in installing novel apparatus. This turbine had over three times the capacity of any predecessor, and its construction, in the state of the art at that time, was a serious undertaking. It showed a high efficiency but not great reliability. Nevertheless, it made history, and, it is believed, gave the promise of success that led other manufacturers to enter the steam-turbine field.

This new prime mover came into competition with the reciprocating engine, then at the pinnacle of its development. Eight 5000-kw engine-driven sets were being installed in the 40,000-kw power station of the Manhattan Railway Company at New York, one of the largest of its day. These gigantic generators stood 42 ft high and the low-pressure cylinders at each end of the shaft towered still higher. But in less than fifteen years, some of the reciprocators were replaced by three 30,000-kw turbines, giving more than double the output of the eight huge engines. Later, more engines were replaced by a 70,000-kw turbine. It was indeed heart-rending to see these monarchs of engineeering achievement being cut into bits with acetylene torches, for they represented the culmination of a century and a half of steam-engine history.

The turbine presented many advantages over the reciprocator. It was of less size, cost, and weight. It required less fuel, lubricating oil, and attendance. It could be built for vastly greater output. Other related instances of foresight on the part of Mr. Westinghouse were his espousal of the LeBlanc-condenser inventions, when his staff could see no virtue in them, and of the reduction gear by which a high-speed turbine could drive a slow-speed ship's propeller, thus rendering the advantages of the turbine available to ships of all kinds.

He was a great general, always inciting his staff to experiment and test. Frequently, he dominated details of design. He was an innate mechanician, but his knowledge of thermodynamics seemed limited, for he was sometimes led to ill-proportioning of the steam path and disappointment. Such occasions often led to unfortunate differences of opinion. I know that, frequently, he regarded me as quite an unfit person to design steam turbines. It was he, however, who introduced an advantageous combination of impulse-and reaction-turbine elements and the single-double-flow principle.



5000-KW WESTINGHOUSE GENERATOR

Withal, he was ever just and considerate, he was the most persuasive salesman I ever knew, be it in a discussion with a possible purchaser or the sale of an idea to a subordinate. Never would he knowingly tolerate an injustice to an employee. He always had sympathy for anyone in trouble; be it a bereavement, sickness, or what not. I vividly remember one occasion; a large and important newly installed machine got into trouble and was temporarily inoperative. It was a serious situation for the company. On the day the news of the accident was received, I was on my way to lunch and saw George Westinghouse approaching. I became panic-stricken but could not dodge. I expected to be party to a painful act of "I told you so." Instead, there were *no* reproaches, nothing but kindliness and sympathy. His sympathetic attitude caused my emotions to get the better of me. Instead of going to lunch, I returned to my office to hide and weep.

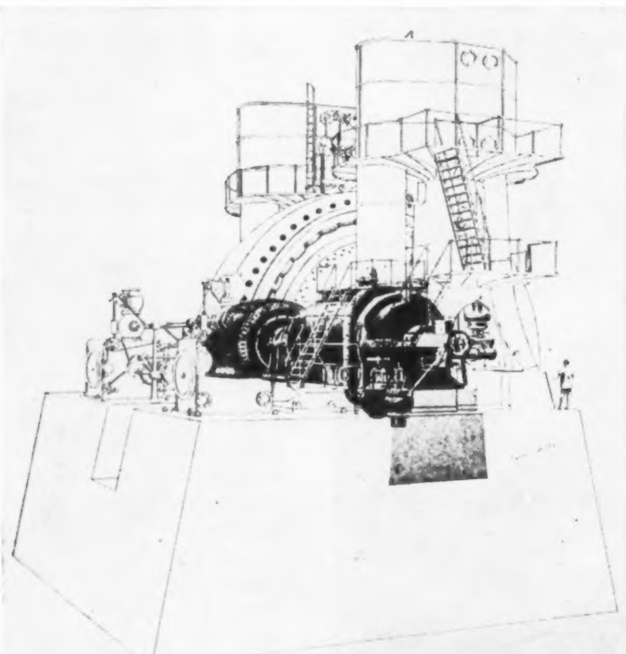
INTERIOR OF MANHATTAN STATION; EIGHT 5000-KW UNITS

THE LEADER: Mr. Hodgkinson has shown why the turbine is suited to produce electric power for a city like New York. The company that supplies most of this power has, as its president, a man who began his career as an office boy in a power

company, of which Mr. Westinghouse became the head. I now request the president of the Consolidated Edison Company of New York to tell us about the turbine in the power stations of New York. Mr. Frank W. Smith.

FRANK W. SMITH: I consider it a great personal privilege to be asked to pay tribute before this distinguished audience to the memory of George Westinghouse on this, the ninetieth anniversary of his birthday. It is true that I began work with one of our predecessor companies, The United States Illuminating Company, afterward the United Electric Light and Power Company, some 57 years ago. The latter company was the pioneer in producing and developing the alternating-current system in New York City. The United States Illuminating Company introduced the Weston series-arc lighting system and later, the limited series-multiple incandescent lighting system. The United Electric Light and Power Company was the pioneer in the introduction of the network system and was the first to apply the network system in its later development in an extensive way. With the perfection of this alternating-current network system in substitution for the old radial system, alternating-current distribution has become the standard of the world.

As a youthful employee, I saw Mr. Westinghouse from time to time, but, of course, in those early days, my contact was infrequent and more or less impersonal. In later years, however, my contact was more direct. I can well remember with what awe and esteem I regarded him. As the development of the alternating-current system proceeded, the operation of this system with an overhead distribution in competition, at that time, with the underground direct-current Edison system was



5000-KW MANHATTAN ENGINE; 5000-KW TURBINE, 750 RPM

an exciting adventure. Our first power was produced by 130-kw belted-engine generators, followed by 750-kw steeple compound-engine sets which were purchased by our company from the World's Fair in Chicago.

I can well remember being in our East 29th Street Station, now the site of the enlarged Bellevue Hospital, with Mr. Westinghouse and Caleb Jackson, an early president of the United Company, at the time these units were installed. On the occasion of one of these visits, the cylinder head of one of the units blew up and went through the roof, returning by the natural force of gravity and disappearing through the boiler-plate floor of the engine room. While this was not a daily occurrence with these units, it was not infrequent, but they were good engines for those days and did the job satisfactorily. If I can remember correctly, when the accident occurred, I beat Messrs. Westinghouse and Jackson to the street by five laps.

POWER SUPPLY OF NEW YORK CITY

REQUIREMENTS— 2,000,000 KW.

COMPARISON ENGINES VS TURBINES

	ENGINES	TURBINES
CAPACITY EACH (KILOWATTS)	7,500 (LARGEST EVER BUILT)	160,000
NUMBER REQUIRED	267	13
FLOOR AREA (ACRES)	17.0	1.2
MEN REQUIRED TO OIL	2000	65
COAL REQUIRED PER DAY (TONS)	26,000	10,000

SAVING

IN COST OF OILER'S LABOR	$ 5,000,000 PER YEAR
IN COST OF COAL	$ 30,000,000 PER YEAR

About 1900, the Edison Company laid out a great station of sixteen 3500-kw generators, driven by Westinghouse engines. These units were considered by many engineers to be so large that the company could never find load for them. About the same time, the Manhattan Elevated Railway was being electrified with power supplied by 7500-kw engine sets. These units were the largest of their type ever built and are about as large as it would be practical to build today.

The steam turbine was invented by Hero of Alexandria, before the Christian era; others, in the last decades of the nineteenth century, built turbogenerators which, however, neither in size nor efficiency, challenged the supremacy of the reciprocating engine, and the world had to wait two thousand years for the genius of George Westinghouse to visualize that the offspring of a union between the plaything of Hero and the alternating-current generator would become the universal burden bearer of mankind. As the prophet Joel foretold, many of our young men have seen visions and many of our old men have dreamed dreams, but to few, throughout the ages, has been given the practical idealism to make so many great dreams come true.

The present power requirements in greater New York are approximately 2,000,000 kw. To produce this power by the monster steam-engine outfits of 35 yr ago, even with their increased rating, would require 267 units. The same output can be delivered by 13 steam turbines of the size now in operation, namely, 160,000 kw. The difference in coal consumption by the two types of unit amounts to 16,000 tons per day, which would load a freight train of 320 cars. The annual saving in coal is about $30,000,000. Thus, the practical idealism of Westinghouse is justified. His rotary type of prime mover, the subject of his first patent, joined with the alternating current, for the development of which he fought so vigorously, constitute our present power unit. The modern power station attests the soundness of his ideals and on a scale probably exceeding his own wildest dreams. This is one of the great romances in the career of George Westinghouse.

IV RAILWAY ELECTRIFICATION

FIRST SINGLE-PHASE CAR, 1894

THE LEADER: The railroad had an alluring interest for Westinghouse. As salesman for his car replacer and reversible steel frog, he met railroad men and learned their problems. Then came the air brake and, later, his switch and signal system and the friction draft gear. But none of these supplied the power that moves the train.

Then, he exploited electric power, entering the street-railway field with a superior motor in 1890. One of his electric-railway engineers recently retired after 45 years of service. N. W. Storer had to do with the development of all types of motor and made notable contributions to electric traction. He will tell the story of Westinghouse and railway electrification. Mr. Storer.

N. W. STORER: The very first time I entered the Garrison Alley factory in the fall of 1891, it was my privilege to see George Westinghouse in action. He wanted to eliminate trolley wires from the streets and to collect current for cars from contacts or "buttons" projecting slightly above the pavement between the rails. He wanted to find what voltage would be safe on the exposed contacts. A short track had been arranged and a horse was ready. He was knocked flat by 110 volts; lower voltages were nearly as bad, and even 10 volts excited him greatly. The test stands out in my memory for two reasons. First, I saw Mr. Westinghouse in action, an experience that thrilled me and filled me with enthuiasm for the *man* and the *work* that I have never lost; and second, I have always felt that although direct current was used in that test, Mr. Westinghouse had in mind, even then, the use of single-phase alternating-current with low voltage on the contacts.

At any rate, B. G. Lamme not long after that produced a 25-hp series motor for $3^1/_3$-cycle current. Two of them were installed on a street car in 1894, and tested on an experimental track with a modified "button"—system, near the Westinghouse residence. L. M. Aspinwall, who tested the equipment, recalled the "terrific" vibration at starting due to the extremely low frequency, but the car was operated for several weeks. The low frequency was not satisfactory, but Mr. Westinghouse would not give up, and eventually Lamme developed a 100-hp motor for $16^2/_3$ cycles, five times the original frequency. Its announcement in 1902 started every manufacturer of electric-railway equipment developing single-phase motors. Mr. Westinghouse had taken a general interest in direct-current equipment and had worked with three-phase motors, but his ideal was a single-phase alternating-current system with high-voltage trolley and low-voltage series motors.

In 1904, the Grand Trunk Railway was considering the electrification of the St. Clair Tunnel. Quick action was necessary, and Mr. Westinghouse decided to build a single-phase locomotive for 25-cycle current to meet the requirements. Before it was completed, he invited the International Railway Congress, meeting in Washington, to come to East Pittsburgh to witness a demonstration of this locomotive and his friction draft gear which had just been developed. They accepted. A train of 50 steel gondolas equipped with the friction draft gear was tested first. It was hauled by one of the largest Pennsylvania freight locomotives. It handled the train well but slipped its wheels repeatedly in accelerating. After a successful demonstration of the draft gear, the steam locomotive withdrew, and the electric took its place. The work of equipping the locomotive had been completed only the night before; so late that no preliminary tests had been made. But to our great relief and joy and to the amazement of the large crowd, containing many of the foremost railroad engineers in the world, the electric lomotive handled the train easily and quietly. The test was a complete success.

The demonstration on that day in May, 1905, led to the adoption of single-phase electrification for the St. Clair Tunnel and also for the New York, New Haven & Hartford Railroad. Incidentally, it may be noted that the St. Clair Tunnel locomotive, after over 20 years of service, was adopted with practically no change by the Pennsylvania Railroad as its standard electric locomotive for switching service. Thus the single-phase system was launched.

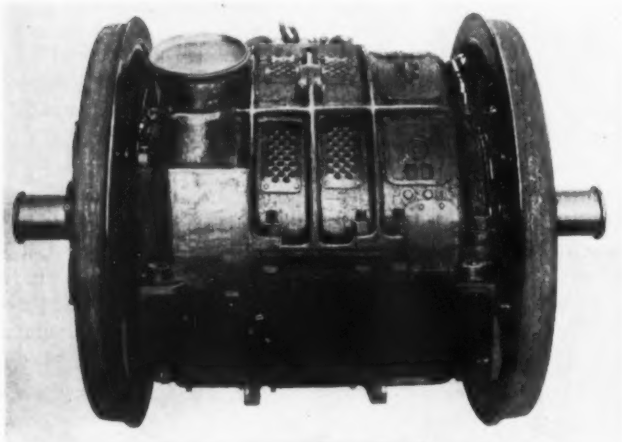
THE LEADER: In taking up, next, the commercial phase of railway electrification I planned to mention the Baldwin-Westinghouse arrangement and to introduce George Gibbs by saying that he had been recommended to Mr. Westinghouse by S. M. Vauclain, of the Baldwin Locomotive Works. But Mr. Vauclain is here, and I have the unexpected pleasure of asking him to speak. Mr. Vauclain.

S. M. VAUCLAIN: It is not necessary, Mr. Chairman, for me to stand before the microphone as I think my voice will reach any person in such manner that he will understand what I have to say. My acquaintance with Mr. Westinghouse dates back to the year 1870. I say "Mr. Westinghouse" because George Westinghouse was always Mr. Westinghouse to me, and I never addressed him in any other manner. I well remember the first application of the Westinghouse air brake on the Pennsylvania Railroad; straight air, the old three-way cock with a brass plug by which the brake could be handled very successfully once you became acquainted with it. Occasionally, the passengers would be shaken up a little, but that was to be expected.

B. G. LAMME, ELECTRICAL DESIGNER; ORIGINATOR OF SINGLE-PHASE RAILWAY MOTOR

Later on, in the year 1890, when I was erecting some new buildings at The Baldwin Locomotive Works in Philadel-

SINGLE-PHASE LOCOMOTIVE USED IN DEMONSTRATION FOR INTERNATIONAL RAILWAY CONGRESS, 1905



NEW HAVEN GEARLESS MOTOR MOUNTED ON QUILLS SURROUNDING THE AXLE

RAILWAY ELECTRIFICATION—NEW HAVEN TRAIN CROSSING HELL GATE BRIDGE

phia, I had a serious talk with Mr. Westinghouse about driving all of our machinery and traveling cranes by electric motors. He remarked that I was taking a pretty big bite. However, notwithstanding his observations, it was decided that we electrify all the machinery and cranes in the building then being constructed, among which were two 100-ton cranes. The great difficulty in their construction was to find motors of sufficient capacity to drive them. The Westinghouse Company had taken over the United States Electric Company; therefore, I went over to see the people in charge, and they advised me that, if I didn't mind the weight, they could convert their lighting machines into motors. I agreed to this, and the order was placed. Those cranes were built and delivered and have been in operation 24 hours a day since the year 1890 and are at present in operation at the plant of The Baldwin Locomotive Works at Eddystone.

In the year 1895, The Baldwin Locomotive Works decided to build electric locomotives, and, in company with one of my partners, I went to Pittsburgh and proposed to Mr. Westinghouse that our two companies join in the enterprise. He promptly agreed to this. It was decided, after due discussion of the project, to secure an expert to be paid jointly by the two concerns. D. L. Barnes, an eminent engineer whose offices were in Chicago, was chosen. Fortunately or unfortunately, Mr. Barnes did not remain with the company very long. He had the idea that something startling had to be designed for electric locomotives, so as to attract attention, something similar to the attention now being given to streamlining of locomotives, cars, and so forth. It so happened that Mr. Barnes and one of our associates went duck shooting, as a result of which he became very ill and died. Our associate recovered after several weeks' illness.

Mr. Westinghouse called to see me immediately after Mr. Barnes's death, and said, "Vauclain, what are we going to do, now Barnes is dead? We have no man, where will we get one?" "Well, that's all right," I said. "I can recommend you the best man in the country, George Gibbs," who was then mechanical engineer of the Chicago, Milwaukee & St. Paul Railroad Company, and now a consulting electrical engineer, of the firm of Gibbs & Hill, in this city. I explained to Mr. Westinghouse that Mr. Gibbs was associated with his brother and with J. N. Barr, then superintendent of motive power of the Milwaukee road, and was operating a small electric-motor-building plant in Milwaukee, and, inasmuch as I had found it difficult to get small electric motors for our machinery, I had given Mr. Gibbs many orders which he had filled to my entire satisfaction. I suggested that, in order to get him, it would be well for Mr. Westinghouse to buy out the Gibbs company and commence manufacturing small motors at the plant of The Westinghouse Electric & Mfg. Co., and, at the same time, turn George Gibbs over to his company and hire him as our consulting engineer on electric locomotives and electrification of railroads. To suggest anything to Mr. Westinghouse that had any real value in it insured prompt action, and, in a very short time, he had bought out the Gibbs Electric Company, of Milwaukee, and George Gibbs became our mutual representative.

It may be well to note here that Mr. Westinghouse was always very much opposed to the third rail for transmitting power, and, today, after more than forty years' experience, the third rail is seldom installed, although some installations are still in use.

The agreement then entered into, between Baldwin and Westinghouse, in 1895, still holds good, with only minor changes, and Baldwin-Westinghouse locomotives are found in all the principal countries of the world.

The Leader: My memory seems a bit slow this afternoon. In 1887, I began my electrical career as wireman at The Baldwin Locomotive Works. One day, I was under a table in the drafting room fastening the wires to the table. I heard a great voice and I came out at once. Had I recalled that incident a few minutes ago, Mr. Vauclain, I would not have suggested that you needed a microphone:

Mr. Vauclain has told us about George Gibbs. As he is unable to be with us today, the other member of Gibbs & Hill will present his contribution. E. R. Hill was testing electric locomotives at East Pittsburgh some forty years ago. Mr. Hill.

George Gibbs: Practical electric traction dates from 1887, when Frank Sprague's Richmond, Virginia, street railway began operation with 500-volt direct-current motors. This system was satisfactory for street cars but was unsuited for long distances or heavy service. As nothing else was available, progress in standard railroad electrification was slow. In the late '90s, alternating current began to be transmitted to substations, where it was converted through rotaries and supplied to the motors. Westinghouse and his engineers contributed to this system. But Westinghouse foresaw that the complete solution called for the flexible and economical distribution of current at high voltage to the locomotive. He advocated alternating current and urged that a common standard might have a future importance comparable to a standard track gage.

The utilization of the current on the locomotive was a second problem. He patented, in 1889, a scheme for converting, on the locomotive, the alternating current into direct current for driving the motors. It is, of course, desirable to avoid apparatus for conversion. The three-phase system uses alternating-current motors, and, although Westinghouse was developing this type of apparatus for general power and although it was used for railways in Europe, yet he held to his ideal of a single trolley and a simple alternating-current series motor for developing the power. It appears that he began work on this system quite early, and, refusing to compromise, he held to his ideal. As Mr. Storer has pointed out, success came a decade later. When the new system was announced in 1902, it was immediately adopted by a number of interurban lines, for which no other economical system was then available. But Mr. Westinghouse's real goal was heavy railroad electrification.

MODERN SINGLE-PHASE LOCOMOTIVE

Immediately following the demonstration of the single-phase locomotive before the International Railway Congress, of which he was president, he showed his confidence and his courage by proposing the new system on one of our most important railroad arteries, the main line of the New Haven Railroad between New York and New England. This important event will be described by the electrical engineer in charge of installation and early operation, Mr. Murray, who sends, by telegraph, his regrets and his contribution, which will be read by Roy V. Wright.

W. S. Murray: As consulting engineer, New Haven System, in association with E. H. McHenry, beginning 1905, it was our privilege to work out, with the Westinghouse Company, the details of the first heavy-traction single-phase railroad electrification, but, behind us all, was the ever-guiding, dynamic, and indomitable spirit of George Westinghouse. He saw and sympathized with us in the seemingly insuperable

EARLY SINGLE-PHASE LOCOMOTIVE

difficulties of the application of a new engineering and construction art, but his great mind, holding principle above all else, never failed nor did ours with his behind us. The New Haven electrification, first branded as a colossal failure, took the measure of the direct-current third-rail system, eliminating its future use forever.

MR. GIBBS: The New Haven experience demonstrated possibilities in reduction of equipment costs and in giving hauling capacity for the heaviest requirements. It was followed by the important installations of the Norfolk & Western and the Virginian Railways and has culminated in the far-reaching installations of the Pennsylvania Railroad. This company had long experience in electric traction with direct current and with the single-phase system for its suburban service out of Philadelphia. The final outcome was the adoption of the single-phase system as used on the New Haven Railroad. I call upon the chief electrical engineer of the Pennsylvania Railroad to tell you of its experience. Mr. Duer.

J. V. B. DUER: Single-phase electrification, adopted as standard on the Pennsylvania Railroad in 1915, after long experience with the third-rail direct-current system which preceded it, has been developed and expanded until it is now used to operate the freight and passenger service between New York, Philadelphia, and Washington, one of the densest railroad traffics in the world. The conception of this system sprang from the genius of George Westinghouse and its development from the efforts of many engineers working resourcefully and intelligently to produce a system fully suitable for important railroad operation. Through the farsighted wisdom of the Westinghouse and General Electric Companies in cooperating in a joint development of locomotive and car equipments, these efforts have recently culminated in the most modern and successful types of power equipment in use on our railroad, and it gives me great pleasure to acknowledge our debt to George Westinghouse and express our profound appreciation for this great contribution to railroading.

MR. GIBBS: Some fifty years ago, back in the '80s, when Westinghouse was evolving a new triple valve and developing an automatic signal system and testing the friction draft gear and investigating the alternating-current transformer and "playing" with his rotary engine, seemingly scattering his efforts over many unrelated fields, no one dreamed, unless it was Westinghouse himself, that they would some day all converge in a single project and produce the premier railway electrification of the world.

V INDUSTRIAL RELATIONS

GEORGE WESTINGHOUSE IN HIS EARLY CAREER

THE LEADER: The air brake inaugurated a dual development; one a mechanism, the other an organization to make it. Westinghouse's acute understanding of the true principles underlying both mechanical operations and human relations enabled him to produce results which have endured. John F. Miller, associate of Westinghouse, long a directing force in the air-brake organization, now vice-chairman of its board, will tell of Westinghouse and industrial relations. Mr. Miller.

J. F. MILLER: It is a notable fact that the Westinghouse Air Brake Company, organized in 1870, has never experienced a general strike. This can be attributed to the attitude of its founder toward his employees. As worker in his father's shop at Schenectady, he naturally inherited the old-time conception of an employer as the head of a family of workmen who was responsible, in a way, for their welfare. In developing his air brake, he spent much time in the shop; a skilled mechanic himself, he often showed the workmen how to do what he wanted done. He knew them; they knew him; there was mutual understanding and esteem, genuine and lasting. And he had an enthusiasm that was contagious; others were ready to do their utmost for him. And, when numbers exceeded the range of his personal touch, those close to him were animated by his spirit and passed it on to others.

Mr. Westinghouse once said to a group of employees:

> I want you to know and feel that no one has your best interests at heart more than I have. We are all interested in the same object, to make this company a success. I have my part in the job and you have yours and, if we all work together in friendly cooperation and with a feeling of mutual good will and good-fellowship, the desired result can never be in doubt.

The genuineness of his motives was attested by his acts. Some of these have been recalled by Mr. Campbell, one of the earliest of his "fellow workers," as he often called them. The veteran has told us of the working conditions in the shop, of the trip to the Centennial, of the Thanksgiving turkeys. And did you note how he unconsciously referred to George Westinghouse, not as if he were a big boss but as to a friendly father?

WESTINGHOUSE IN THE FACTORY

Increasing numbers led to difficulties in giving turkeys, and Mr. Westinghouse, though loath to give up the personal expression of good-fellowship, was induced to devote the turkey fund of $10,000 to the Westinghouse Air Brake Pension Fund. That early adventure into "social security," now the subject of so much discussion and new legislation, I cannot now describe in detail. It, however, developed into the broadest and most liberal

provision for the "social security" of employees, of which I know. The fund now approximates $2,700,000; the total benefits paid have exceeded $3,000,000.

The removal of the air-brake plant, in 1890, to a location 15 miles from the city was a new sort of industrial venture. It involved not only the building of a factory but also the planning of a new town, including water supply, modern power system, and erection of dwellings. In all these problems, Mr. Westinghouse took keen personal interest, especially in those affecting the health, comfort, and well-being of his workmen. As a result, Wilmerding secured one of the earliest up-to-date sanitary sewer systems. Baths and toilet facilities were installed in the dwellings, which were far better than the average small dwelling house in the Pittsburgh district. Through a monthly payment plan, including life insurance, many employees became owners of their homes.

Social, educational, and recreational facilities were provided and substantially supported by the Company. The Wilmerding Christian Association, the agency conducting the enterprise, now has a paying membership of over 3300 men, women, and children. The town itself, a hamlet of a few houses in 1889, now has a population of 6300 and a taxable valuation of over $7,000,000.

In paying tribute to his attitude, I cannot refrain from mention of his brother, Herman Westinghouse, member of The American Society of Mechanical Engineers, a leader in the Air Brake Company for nearly fifty years until his death in 1933. In employee relations, he also was a shining example of the Westinghouse spirit of cooperation. He and his older brother have left to the company a rich heritage in their practical exemplification of loyalty and tolerance and good will.

The Saturday half holiday, granted in June, 1888, by the Air Brake Company, appears to have initiated a new practice among large industries. It had an interesting origin. When young George was working in his father's shop at Schenectady, he resented the stern discipline of those days which kept him from playing ball with the other boys. He is reported to have said to his father, "If ever I become an employer, I'll give everybody Saturday afternoon for a holiday." The ideals of the boy became the policies of the man.

The following reported utterance of Samuel Gompers, founder and first president of the American Federation of Labor, after an intense but unsuccessful effort to unionize the Westinghouse Electric & Mfg. Co., is perhaps the most significant as it is the most notable tribute to the Westinghouse spirit.

"I will say this for George Westinghouse. If all employers of men treated their employees with the same consideration he does, the American Federation of Labor would have to go out of existence."

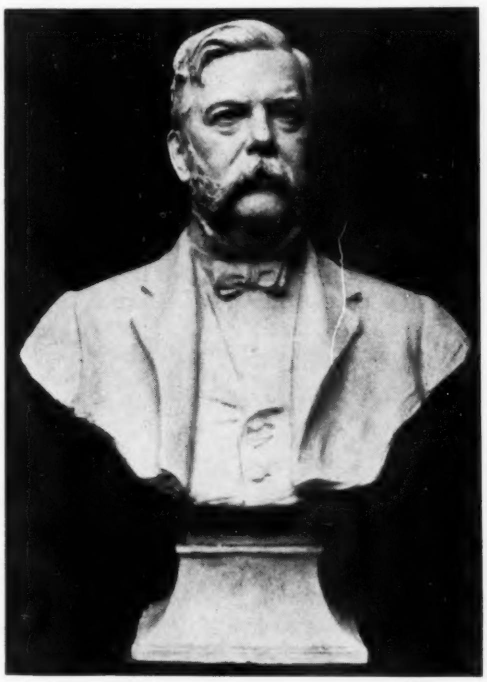
What was the dominating purpose of Westinghouse? It was not to get money, except as a means for extending his activities. Usually reticent, he once told a personal friend of his supreme desire "to do something which would contribute to human comfort and human happiness." When we contemplate the new industries he created, with their opportunities for useful employment in producing new products which continue to contribute to human comfort and happiness, we see that few men have so fully realized their chief ambition in life as did George Westinghouse.

EPILOGUE

C. F. SCOTT: Mr. Chairman, in your opening sketch of Westinghouse, you said that he made the work of Watt and Stephenson and Faraday vastly more effective. Our reminiscences show concretely how he did it, how he amplified the usefulness of power and transportation and electricity, three great agencies of applied science in the progress of civilization. We have traced great achievements from simple ideas in his habitual quest for a better way to do things. His magic wand was persistent effort; urged to take a vacation for pleasure, he replied, "Work is my pleasure."

A gift for quick concentration and an unusual memory enabled him to shift rapidly from one of his many activities to another. Some ideas matured quickly; some major projects required a decade; others, several.

Colonel Prout, in "A Life of Westinghouse," indicates his preeminent traits as imagination, fortitude, serene courage in adversity, audacity, persistence, concentration, memory, association, resourcefulness, complete self-reliance; a good deal more than a genius, he was a man of balanced character, of high and simple standards, strong and gentle, acute and sincere. These qualities supplemented his heritage of health and intellect and character. Dominated by a dynamic personality and an invincible will, he was an outstanding figure in the Engineering Renaissance which preceded the turn of the Century.



WESTINGHOUSE BUST BY DANIEL CHESTER FRENCH

In developing new things, his great satisfaction was the creating of new industries giving useful employment to many men. Gaging his success in dollars, the payrolls of his company have aggregated billions. And his industries aided others by furnishing machinery and power.

But, in larger terms, his whole career offers a solution to a pressing problem of our new industrial order. He solved technological unemployment by creating new employment, new inventions, new industries. His aim was not the accumulation of riches but the creation of new wealth.

He was a pioneer leading the way through the perplexities of a confused and changing civilization to the realization of its new possibilities.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While no quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

Engineering Unity

INDIANA ENGINEERING SOCIETY

AT A meeting of the Indiana Engineering Society held on February 16, 1937, James H. Herron, president, The American Society of Mechanical Engineers, spoke on "Unity in the Engineering Profession." This much-discussed subject has been frequently treated in MECHANICAL ENGINEERING and is of such vital concern that the principal points made by Mr. Herron have been condensed and summarized so that they may reach a wider audience.

Mr. Herron broadly classified the advantages of unity as those of a technical and those of a material nature. Technical advantages derive from a more simplified practice, standards of form, material specifications and proper classification, and technical cooperation where practices overlap or conflict. Mr. Herron mentioned the American Standards Association, the American Society for Testing Materials, Engineering Foundation, the American Engineering Council, and the Engineers' Council for Professional Development as indicating the good work on behalf of technical unity already being done by the profession.

As material advantages of unity Mr. Herron listed those which are to be found in national and local civic affairs, legal status, fees, compensation, ethics, methods of practice, publicity, welfare, and publications. In this classification he noted certain lacks which he discussed briefly.

Engineers get little publicity in the public press, he asserted. While this condition might be corrected, it would be necessary for engineers to permit their accomplishments to be popularly dramatized, without sacrifice of the truth, by proper word painting in a manner that would be attractive to the man in the street.

The registration of engineers, he asserted, was also an important agency of recognition, as it legally set the standard for admission to professional practice. Furthermore, it provided protection from those who would practice without qualification.

In commenting on the engineering profession in national civic affairs, Mr. Herron referred to the American Engineering Council, and quoted from A. A. Potter's address as president of the Council on the work that organization is doing through its 48 affiliated bodies in endeavoring to present for the profession a united front in matters pertaining to government and public affairs. Examples of participation by engineering groups in local affairs were also cited.

Such matters as engineering fees, compensation, welfare, codes of ethics, methods of practice, and publications were, said Mr. Herron, characteristic, in general, of each separate branch of the organized profession and had not been designed to apply to others. To him there seemed to be no well-defined effort to coordinate and modify such regulations for the common advantage of all.

In attempting to answer the question, how to accomplish what is desired in the way of professional unity, Mr. Herron stated his opinion that engineers had been remiss in utilizing the power that lies in the magnitude of their numbers and in marshaling their forces to function to their maximum potential capacity. An organization of 100,000 engineers, he said, can command a powerful influence in any civic or social movement when presenting an unbroken front and directed by inspiring leaders. The very activity manifest by the organization which discharges its debt to society, he said, at the same time establishes and enhances the prestige of the profession.

Are there any advantages not covered by the present setup of technical societies? asked Mr. Herron. Clearly, he said, the societies can function best in those technical lines which differentiate them and they should continue to retain full and unrestricted power to carry out their aims. But in the material accomplishment of organized effort where interests are common to all engineers, a common ground may be found on which to build a structure of unity.

Two plans for unification had been suggested, he asserted. One of these seeks to add to the present constituted societies, confining their activities to technical topics, one or two others to cover the needs. Under the second plan, adopted by the medical and legal professions, local and state organizations, embracing all professional engineers in whatever branch they practice, are set up. The local organization constitutes the unit. These organizations are united to form a state society, and from the state societies a national organization of engineers can be effected.

What engineers might do along these lines toward unity and coordination had long been on his mind, Mr. Herron confessed. Primarily, this should be along material lines, and should start with the smallest unit, as thus difficulties encountered could be ironed out and state and national groups would reap the benefit of experience and accomplishment.

An alternative plan which might be effective and which would entail less friction to set it in operation was also advanced by Mr. Herron. This would be to let each society differentiate between technical and material affairs and arrange a committee for each division. In matters strictly local the committees on material interest from each local section of the various societies could organize to do what is needful. Representatives of all local societies would constitute the state organization. In a similar manner a national body could be constituted.

The chief arguments for this plan, said Mr. Herron, were that it involved the least amount of educational propaganda to secure the assent of the profession, that it involved no new or complicated machinery to initiate its execution, that it neither destroyed existing societies nor needlessly created new ones, and that it would be the least expensive in terms of added membership dues.

Research, Gifts, and Researchers

SCIENCE

SIR WILLIAM BRAGG, in an anniversary address delivered on November 30, 1936, spoke of scientific research under the auspices of the Royal Society, of which he is president. From *Science*, for February 12, 1937, the following portions of Sir William's address have been assembled.

Sir William began by announcing that the Council of the Royal Society had accepted a principal share in the responsibility for the administration of a sum of £200,000, the interest on which was to be applied to the encouragement of research in metallurgy, engineering, physics, and chemistry. This led to some comments on research, research gifts, and research workers, with concluding remarks on work recently conducted by the Royal Society.

Even those who have it that science must be followed without thought of its usefulness, said the speaker, must admit that it has to be very pure science indeed which only meets with its application, as a straight line meets its parallel, at infinity. In general the encounter may be expected to come so soon that its effect has a present importance, and must be taken into account. The individual member of the society may keep his thoughts and his experiments within an isolated region, but the society as a whole must take a wider view and watch constantly the relations between scientific advance and the people who are affected by it. It accepts these responsibilities when it undertakes to administer the great sums that have been entrusted to it.

The increase of knowledge and its applications are, each in its own way, worth working for, he said. There follows an increase in the quality and quantity of men who can add to knowledge and use it, and, it is hoped, an increase in the number of those who realize its effectiveness. History has shown how the fate of a nation may depend upon its capacity to use the knowledge and the materials at its disposal.

The past differs from the present, he continued, in that the knowledge then to be drawn upon was scantier and less abstruse. Today, great matters turn on the complicated science of the wireless valve, or the intimacies of the internal-combustion engine, or the highly skilled chemistry that brings assistance to mechanism, or the combination of physics, chemistry, biology, and engineering involved in the preservation of food.

From this point of view, he argued, the suggestion sometimes made that scientific workers might take a holiday looks more ridiculous than ever. No nation could afford such an intellectual disarmament in the face of the world; nor could the world itself in the face of the evils to be overcome.

He then commented on the position of the men, particularly the younger men, who are encouraged by financial aids to devote the most ingenious years of their life to scientific research. Some of the most brilliant young men in the Empire, he said, are selected for a specific purpose, which purpose they undoubtedly fulfill. Good work is done, and when it is finished a fine and most useful type of man is available for further service. In a great number of cases the satisfactory opportunity of further service presents itself. But it is not always so. It is possible to find a man living on income derived from one research trust after another until he ceases from age or other limitations to be eligible for further aid. His work may have been excellent, and his competence as great as ever, but he finds that he must look in some new direction for his living. Academic businesses may be of no use to him, nor he to them. His occupation has led him up to a blind alley. There is a certain tendency for men who have been employed in industry as research workers to change over, where possible, to purely administrative work which is expected to be more lasting and in the end more remunerative There is here a hint as to the true cause of the trouble. The blind alley should be a thoroughfare leading to occupations more suitable to the men and better fitted to get the best out of them. It is obvious what these occupations are. They are places of responsibility to which specialists in science are as yet but rarely admitted. There is an encouraging beginning but it takes time to realize that the man who is in touch on one side with the growth of natural knowledge should be in close touch on the other side with the opportunities of its application. He should be an equal in the council chamber rather than a subordinate in the waiting room. On the other hand, the scientific expert must himself help to take down the barricade that makes the alley blind. This requires that his education should be much more than sufficient to make him only a laboratory man: which brings us back again to the very important point that the man himself must be as much the care of those who give him research work to do, as is the work which they set before him. Obviously, the more complete the equipment of the man, the better the chance that he will make his way, and the wider his final influence. The bodies that administer research funds are already beginning to consult each other for the sake of better efficiency in the choice and direction of workers. As this becomes more general, there will surely be an effort to take a wider view of the responsibilities which the magnificent generosity of public men has placed upon them.

Can Management Use Economy

NEW YORK MANAGEMENT COUNCIL

IN COMMON with bankers, industrialists, engineers, and other groups, economists have been accused of false leadership before and during the depression. While the justice of the accusations is refuted by each group there is, nevertheless, a sincere desire on the part of those accused to strengthen the esteem in which they are held by the public and to make more effective the cooperation which can and should be extended by each group to all others.

Evidence of this desire to cooperate and an indication of some practical way in which it might be made effective were presented in a paper by Charles F. Roos, director of research, Mercer Allied Corporation, New York, N. Y., and secretary of the Econometric Society, at a meeting on February 9 sponsored by the New York Management Council in which some 26 engineering and management groups participated.

Doctor Roos spoke on "Expected Contributions of Economic Theory and Measurement to Business Management." After reviewing briefly such questions as, What is economics and how did it develop? Why has modern business given so little heed to economic theory and measurement? What are economic facts and how can we measure them? What is a proof and how do we prove economic interrelations? How can management act on hypotheses that are proved? What discoveries in the fields should be utilized by business management? Doctor Roos gave some examples of recent attempts to measure economic interrelationships.

From these examples he argued that it can no longer be said that management has not been able to utilize economic measurement. The problem remaining, he said, is to find various new ways in which the two can be brought more

closely together, and he suggested that management might consider the feasibility of establishing departments of economic research manned chiefly by economists who have had the courage to master difficult mathematical and statistical techniques.

We might next ask the question, he continued, Should the executives in each department be trained economists in addition to possessing their other qualifications? The answer to this question, he said, was, Yes, to a certain extent, for they must be able to pass judgment upon the findings of an adequate economic group associated with the organization, and primarily, they should be in a position to select men whom they can trust to present a thorough economic analysis of each problem.

In Doctor Roos's opinion the modern economist should possess the following qualifications:

(1) He should be trained in the abstract fields of logic, mathematics, and statistics.

(2) He should be trained in economic theory. This we have defined as the science of the interrelationships among wealth-getting and wealth-using agencies.

(3) He should have an interest in psychology, law, politics, etc. so as to understand human wants and desires and their significance in the control of human efforts.

(4) He should be broad- or open-minded, not dogmatic.

(5) He should be able clearly to differentiate between formal analysis and empirical science. In other words, he should understand the rôle of hypothesis and so-called facts.

(6) He should be one whose opinion is welcomed and respected by the practical manager. He probably ought to report to a member of management.

(7) He should be able to report his findings in nontechnical language.

The duties of economists in business were briefly described as follows:

(1) The economist should act as a liason between management and economists on technical aspects of economic problems. Thus, he should promote a closer cooperation between these economists who are evolving economic theory and those business men who are making economic reality.

(2) He should bring important contributions in economics to the attention of the right man in management. All discoveries reported at scientific meetings, in economic and statistical journals, in publications of independent economic bureaus, and elsewhere should be summarized with respect to the bearing that they have on the immediate and long-range policies of the business. Copies of such summaries should be made available to management throughout the corporation. A survey now being made shows that business is paying increasingly more attention to the output of the National Industrial Conference Board. This is as it should be. A properly functioning economist would promote this movement and make available also to the management, the economic output of other organizations.

(3) He should advise management and all others within the organization when called upon in much the same way as an attorney does. Thus, he should take the initiative in calling economic aspects of the business to the attention of management and should be prepared to give advice on current economic problems as they arise.

(4) He should take an active part in cooperating with established societies and institutions in the field of economics, such as attending meetings, giving papers, and serving on committees.

Thus we believe, he said, that every large business should have at least one economist who would call the attention of the management to all pertinent discoveries in the field of economic measurement. The larger businesses should have economic departments related to management in much the same way as their legal departments now are. Moreover, managers should also endeavor to read current general works on economic theory so as to prepare themselves to understand the report prepared by these departments. And most important they should take time to read the reports and ask for conferences so as to thresh out any obscure points.

Dr. Roos concluded by suggesting that several economic research institutions and engineering and management societies might be asked to prepare a report on the question, How can we get more economics in management?

Following the presentation of Dr. Roos's paper, this concluding suggestion was put in the form of a resolution which was unanimously approved by those present.

Precooling Aircraft

FLORIDA SECTION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PRECOOLING of passenger transportation units, resorted to by the railroads during the period when coaches were being rebuilt to provide for air conditioning, has been taken up by certain air lines, as John J. Tigert, of Pan-American Airways, reported briefly at a meeting of the Florida Section of The American Society of Mechanical Engineers held at Miami last December.

Mr. Tigert made clear the fact that an airplane in flight needs no cooling, even in equatorial regions, when traveling at an altitude of 5000 ft. Excellent ventilation can be secured by utilizing small scoops on the sides of the hull or fuselage and distribution ducts running the length of the cabin. Dampers and heaters supplied from engine exhaust make it possible to regulate air volume and temperature within wide limits.

In port, however, ventilation in airplanes is poor, and, when the weather is warm, temperatures in the cabin may be 10 deg in excess of those outside. Hence precooling is utilized.

Mr. Tigert described a precooler, still in the experimental stage, developed at Miami. It is of the ice-melting type with a capacity of about 600 lb of ice. Its refrigeration capacity is in excess of three tons with an output of approximately 1700 cu ft of air per min and an overall thermal efficiency of 73 per cent. It is mounted on rubber-tired casters and can be easily handled by two men. It has demonstrated its ability to lower the temperature of the largest clipper ships from 10 deg above the outside air temperature to 4 deg below it in approximately 15 min with front and rear hatches open and men working in the cabin.

The air is introduced into the cabin through the ship's ventilation system, which provides a manifold for uniformly distributing the air through all compartments. The delivery duct from the precooler is held in place over the air scoops on the sides of the hull by means of button-type snap fasteners, reducing the attachment and detachment time to a minimum.

Experiments have also been conducted at Brownsville, Texas, he said, on precooling with carbon-dioxide snow. Fifty pounds of bottled carbon dioxide were released inside the cabin of a Boeing 247 transport which has a volume of 700 cu ft. The discharge was directed against the walls and ceiling and deposited carbon-dioxide snow throughout the cabin. The temperature drop was instantaneous and amounted to about 10 F. The cabin was closed and the time required for returning to the original temperature was about 1.75 hr.

As the plane tested was standing in the sun, the insulating properties of soundproofing were displayed. The relative humidity rose from 55 to 67 per cent, returning to normal with the temperature.

The simplicity and speed of this method of precooling, known as "flash-cooling," he concluded, have attracted attention. However, it should be said that when a plane has been standing on the ground for 12 hr or more, the air in it is not only hot, but is apt to be contaminated with objectionable fumes and odors. Cooling this air directly by "flash-cooling" is only a partial solution to the problem, for the air lacks in vitality and is far from refreshing, even though cool. The more satisfactory solution involves the displacement of this hot, stale air with fresh air from the outside. The "flash-cooling" method is, therefore, best adapted to short stops en route.

Neoprene—A Synthetic Rubber

E. I. DU PONT DE NEMOURS & COMPANY, INC.

IN A du Pont news bulletin dated February, 1937, which has been put together in a manner to deserve commendation, is told in nontechnical language the story of "neoprene" (formerly sold under the trademark "DuPrene," described as "the generic term for chloroprene rubber and for products made from chloroprene rubber by compounding it with appropriate vulcanizing agents, pigments, etc., and vulcanizing the mixture."

The first step in the manufacture of neoprene, says the bulletin, is to heat coal and limestone in an electric furnace, thus producing calcium carbide, from which, with the addition of water, acetylene gas results. This acetylene gas is then treated with a catalyst and a previously unknown chemical substance, mono-vinyl-acetylene, is formed. In another catalyst chamber this substance is caused to combine with hydrogen-chloride gas, producing a liquid called chloroprene. By means of a polymerization process this liquid is converted into a tough, rubber-like solid known as neoprene.

Neoprene resembles natural rubber more closely than any other artificial product. The X-ray discloses that its physical structure is the same even though its chemical composition is different. It looks like crude rubber shipped from the rubber plantations and is mixed with other materials, processed, and vulcanized by rubber manufacturers just like the natural product. But although the finished articles look like those made of crude rubber and have the same elasticity, stretch, and toughness, they also have the ability to resist the action of oils, gasolines, and solvents which destroy rubber. They resist heat, and direct sunlight does not cause them to check and crack so readily. They resist the passage of gases and have a much longer, useful life than like articles made from nature's product.

Because of these many advantages, chloroprene rubber is being used by industry in great and increasing quantity. Some of these applications are:

Hose lined with neoprene is being made for conveying gasoline, oils, gases, solvents, and chemicals of all kinds.

Gaskets and packings of neoprene are in use where oil and heat would normally make rubber gaskets unsuitable.

Printers are using rollers of neoprene composition, replacing glue-glycerin and rubber compounds, and printing plates are being made from it.

Electric wires are protected by neoprene jackets from the effect of oils, chemicals, heat, sunlight, and the ozone formed around high-tension conductors. Balloon fabric of neoprene composition holds hydrogen and helium gas better than natural rubber.

Belts for transmitting power and conveying materials are covered with compounds made from neoprene.

Refrigerator seals are made of neoprene, and also gloves for the chemical industry.

Diaphragms, hospital sheeting, tank linings, sealing strips, and many special products have this new chloroprene rubber as a base.

An artificial latex known as neoprene latex may be made by polymerizing an emulsion of chloroprene in water. This latex looks just like the milk of the rubber tree but differs from it in that its particles are much smaller. When the latex is spread out into a thin film or impregnated into a porous body, there remains a film or deposit of neoprene which has the same strength, toughness, and elasticity as vulcanized rubber but also has the special stability to air, sunlight, oils, and chemicals for which neoprene is noted.

It will be seen that many of these uses are in fields complementary to or beyond the capacity of natural rubber. The producers see a good possibility of widening this market by decreasing the cost of manufacture and, consequently, the price of neoprene. With raw materials cheap and in unlimited supply, the price of neoprene in the long run will depend on how much can be sold. It will depend also on the genius of the laboratory men in still further simplifying the process of manufacture.

Spoor of Civilization

INTERNATIONAL TIN RESEARCH AND DEVELOPMENT COUNCIL

WHEREVER civilized man is to be found today a spoor of abandoned tin cans marks his trail, as the shell mounds and kitchen middens, turned up by archeologists, show where his prehistoric ancestors once had their homes. By this simple and inexpensive device, foods and other devices, perishable or easily dissipated without an adequate container, may be preserved indefinitely, easily stored and transported in large or small quantities, and made instantly available for use. What this means to the economy of civilization and to the standard of living is too far-reaching to be easily stated or overemphasized.

The industries, machinery, and techniques concerned with tin plate and tin cans in the United States are described and profusely illustrated in Bulletin No. 4, issued in October, 1936, by the International Tin Research and Development Council. This 144-page bulletin with its 159 illustrations, issued free, was prepared by the Battelle Memorial Institute, founded by the son of Col. John Gordon Battelle, who operated an experimental plant for demonstrating the manufacture of tin plate in this country in 1891, from which date, the Bulletin states, has developed the enormous tin-plate industry in the United States.

The comprehensive review of the manufacture of tin plate and tin cans which comprises the bulletin is so abundantly provided with illustrations that the picture-minded reader can obtain a fairly complete idea of its contents from them and the captions alone. But the engineer who dips more fully into the text will find much to interest him, told simply and clearly in nontechnical language. Every element in the process from mine to consumer is covered, with the historical background and statistical summaries for those who wish a well-rounded view of the industries concerned as well as a description of their methods and machinery.

A concluding section is devoted to the future of the tin-plate industry in the United States in which it is stated it is now in a healthy, prosperous condition and gives every indication of remaining so for some time. There is no large excess producing capacity nor anything approaching a shortage in capacity. Production is so divided among a large number of independent companies that fair prices and constantly improved products are warranted by commercial rivalry. The cooperative attitude between tin-plate manufacturers and can-making companies has facilitated research and stimulated developments. The threat to a portion of the tin-plate industry in the development of aluminum-coated steel sheet is not considered serious at the present time.

Improvements in the manufacture of the base metal, now in progress, hold promise of extending the range of application of tin plate. Mention is made, in this connection, of cold-rolling technique, pack rolling, the Hazelett process of casting the base metal into a long thin ribbon instead of large billets, electric and gas annealing, continuous production, and mechanical abraders as a substitute for pickling. Improvements in tinning and developments in the manufacture of tin-plate articles hint at other problems engaging the attention of engineers in these industries, and a brief discussion of new applications of tin plate encourages the belief that expansion of markets is not being neglected.

Aerogel

INDUSTRIAL BULLETIN OF ARTHUR D. LITTLE, INC.

FROM the *Industrial Bulletin* of Arthur D. Little, Inc., is reprinted in what follows a brief note on aerogel, in the hope that it may be suggestive to engineers whose eyes are peeled for new materials.

Jellies of such typical materials as agar-agar or gelatin are composed of a felt of minute fibers plumped out by water, which is held tenaciously in this fine network by capillary attraction. When a jelly dries down, the felt collapses to a film, but this can usually swell up again to the original volume if soaked in cold water. Several years ago, Professor Kistler, of the University of Illinois, devised a process whereby the water of a jelly could be displaced by a liquid such as alcohol, leaving the jelly mass in its original volume, and then by converting the alcohol carefully to a gas, leave the felt in the uncollapsed condition. This pithlike form which is called "aerogel" can be secured not only with the jellies already mentioned, but also from the jellified oxides of silicon, iron, nickel, tin, titanium, aluminum, and other elements. The aerogel of silica under the name of "Santocel" is now available for commercial use, and its producers are seeking practical applications.

Silica aerogel comes as a powdery mass of extreme lightness; soft and compressible. Bulk weights are four to ten pounds per cubic foot. If kept dry, it is a good insulator and has been suggested for thermos bottles, household refrigerators, and ice-cream cabinets. It is also suggested as a bulker, especially for alkali powders, for the silica is readily soluble in alkaline solutions. Such ready solubility provides a means for preparing the silicates of organic bases.

Aerogel possesses the remarkable property of mixing rapidly and uniformly with pigments. When a tube containing a considerable bulk of aerogel and a small proportion of colored pigment is shaken once or twice, a uniform mixture is obtained. This provides a most spectacular demonstration of its exceptional dispersive properties which may find practical application in paints and lacquers.

A number of interesting uses follow from the remarkable behavior of aerogel with liquids. Certain grades are said to adsorb up to 80 per cent of their volume of water without getting "wet." After that, a paste is formed. Aerogel is thus of value in drying up watery liquid compositions. It may also be used in making thick greases from thin oils, and has been suggested as a suspending aid for the pigments in paints and printing inks.

Cooling for Summer Comfort

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

PERSONS who carry ear muffs in the summer to put on when they enter air-conditioned moving-picture theaters and who shudder at the sudden transition from the torrid train shed to the frigid Pullman will be glad to know that engineers are doing something about this latest *bete noir* of the machine age.

From the *Official Bulletin*, February, 1937, of the Heating, Piping, and Air Conditioning Contractors National Association the following summary of a paper on "Cooling Requirements for Summer Comfort Air Conditioning," read at the St. Louis Meeting of The American Society of Heating and Ventilating Engineers, January, 1937, is taken. The paper reports tests made in Toronto, College Station, Texas, and Pittsburgh under the supervision of the Technical Advisory Committee on Comfort Requirements for Summer Cooling, of the A.S.H.V.E., by, or in cooperation with, the research laboratory of that society.

Says the summary:

The study of the cooling requirements for comfort in summer air conditioning in Toronto, Texas, and Pittsburgh confirms the findings of a year ago that comfort may be had over a small effective temperature range, which is independent of daily or even weekly variations in outside weather. The results show clearly that with the weather conditions of last July in Toronto, an effective temperature of from 2 to 3 F lower was required for comfort than was the case in Pittsburgh. Similar studies made in Texas prove rather conclusively that for their hotter, more continuous, and longer summer heat, the same effective temperature is required as was found for Pittsburgh. In Toronto, 70 per cent of the subjects were found to be comfortable over a range of effective temperatures from 68.5 to 71 F; in Pittsburgh from 69.5 to 74 F; and in Texas from 71 to 74 F.

In order to minimize the cold shock upon entering a conditioned space, as well as to economize in the cost of cooling, an optimum effective temperature for air-conditioning purposes is recommended near the upper limits of the comfort zone, or 71 F effective temperature for Toronto, and 73 F for localities having summer conditions as hot or hotter than Pittsburgh.

An intensive study of the relation of comfort to relative humidity with constant effective temperature indicates little or no measurable variation in the time required for perspiration to disappear and for comfort to be established in a relative-humidity range from 20 to 90 per cent. However, a recommendation for the use of relative humidities of 80 per cent or higher must be given with reservation, due to the difficulty experienced in properly supplying these higher humidities in the summer with the air-conditioning system available.

Sixty-one men, ranging from 20 to 65 years in age, were found to be comfortable over approximately the same temperature range as the trained, young subjects. A slightly higher temperature was indicated as desirable by men over

forty. Few data were obtained for women of different age groups under satisfactory weather and environmental conditions, but these few observations indicate no material difference in the degree of cooling desired over that found for men.

Clothing was found to have a material effect on the desired temperature for comfort. The wearing of a lightweight coat apparently decreases the temperature required for comfort by 2 to 3 F. Hence, the removing of such a coat raises the maximum temperature for comfort by 2 or 3 F.

The Spirit of Science

WATERBURY SECTION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

When introducing the speakers at a recent meeting of the Waterbury section of The American Society of Mechanical Engineers, A. L. Davis, the chairman, voiced some comments on the engineer's obligation to society in which he alluded to the spirit of science as the hope of mankind. From these introductory remarks, which favorably impressed those present, the following excerpts have been made.

A while back we heard the complaint that the engineer was to blame for technological unemployment because he improved the productive capacity of labor-saving machinery too rapidly. Later it was admitted that the too rapid introduction of such equipment was not the fault of the creative engineer but the lack of balanced judgment on the part of executives who made the transition from the old to the new too abruptly. Thus the engineer stands freed from that accusation.

However, there is another responsibility, and one of greater gravity, which, I think, the engineer must be asked to assume. It is the responsibility of one who has been trained in the scientific *method*—who may be presumed to be imbued with the scientific spirit—to extend the application of that spirit and that method into a new field—into the vast domain of human relations, especially in the realm of industry and of government.

Mankind is strongly imitative, and may be influenced and led by example where he cannot be forced by precept. Collectively the engineers of our country can exert a great influence through the force of their example. Here is where every one of us has a duty to perform the duty of exhibiting in ourselves, and of supporting in others, the spirit of right reason—the spirit of tolerance, fairness, and respect for the rights and feelings of the other fellow—whoever he may be. In a word we must demonstrate the scientific attitude of mind in the everyday relations of society. We must strive to make our demonstration so admirable that observers will be filled with the desire to do likewise. The more ably we translate scientific impartiality into the work of social relations, the more others will seek to use the same method. Surely the collective example of all scientifically trained men can show that there *is* a *better* way, a *winning* way, a way that will secure more for everyone concerned, than the old hammer-and-tongs method of settling controversies, whether they be industrial, governmental, economic, or international.

What are the distinuishing features of the proposed extension of the scientific spirit and method into social relations? Each of us might put it into slightly different words, but the following is suggested as a rough attempt.

The animating spirit shall be that of fairness, impartiality, and reasonableness. In a controversy, right reason insists that all sides be presented, that each have a full hearing, and that the good points in each be acknowledged. It admits the difficulty of obtaining exact truth, and hence the liability of error in decisions, which, therefore, are considered subject to revision whenever better information is available. It depends on patient and honest work, investigation, and conciliation. It seeks human understanding, and to engender mutual consideration and respect.

In the spirit of science lies the hope of mankind. So let each of us try, as best he may, to exemplify the spirit and method of science in his dealings with men. Thus may engineers do as much for our social relations, as they have done for our economic welfare.

Goggles

NATIONAL SAFETY COUNCIL, INC.

Safe Practices Pamphlet No. 14 of the National Safety Council, Inc., devoted to goggles, is based on the accident-prevention experience of a number of employers. It is not to be confused, therefore, with federal, state, or insurance requirements or with national safety codes. It answers briefly the questions, "When should goggles be worn?" and "What kind of goggles should be worn?" and describes such elements of goggles for various uses as frames, eyecups, lens containers, connectors between lenses, side shields, attachment devices, and lenses. Brief comments on sterilization and tests are included.

In a section devoted to the problem of getting men to wear goggles, sometimes a difficult procedure, it is suggested that after the question, couched in positive rather than negative form, "Can an eye be injured on this job?" has been answered in the affirmative, an order should be issued by the executive head of the company stating the facts and specifying what types of goggles are to be used. After such an order has been issued it must be rigidly enforced.

The purpose and importance of wearing goggles should be explained to the men. Instances where the use of goggles has saved the sight of fellow workers or of workers in other plants should be referred to. Where possible, a photograph of a worker with the goggles which have saved his sight, and an account of the accident, may well be posted on the shop bulletin boards. Reference is sometimes made in the company's magazine to causes of eye accidents, their number, and how such accidents may be prevented.

In one large plant, after an order was issued that goggles were to be worn in certain places and during certain operations, all supervisors, regardless of their position in the organization, the safety man, and all visitors to that plant set a good example by wearing goggles in compliance with the order.

The method of supplying goggles differs in various plants. In some instances the main supply for all shops is kept in the main supply department. In other cases the various shops maintain their own supplies. For the sake of uniformity it is better to have the main supply kept in a central department. However, it is important that each shop keep on hand, always ready for use, an adequate supply of the goggles needed in that shop. A sufficient supply of repair parts should also be kept in each shop unless there is a central goggle-repair department, or unless the broken goggles are periodically returned to the manufacturer for repairs.

When a man will not wear goggles, in violation of orders, and after every effort has been made to explain the necessity of his so doing and to provide goggles that are suitable and comfortable, he should be disciplined.

Boring a 5-Ft Mine Shaft

MINING AND METALLURGY

ENGINEERS in general are familiar with rotary drilling of wells and with core drilling by means of which the earth is explored preparatory to the building of foundations and other engineering structures. In the September, 1936, issue of *Mining and Metallurgy*, J. B. Newsom, of the Idaho Maryland Mines Corp., San Francisco, describes an adaptation of this familiar technique to the boring of a 5-ft mine shaft 1125 ft deep.

The walls of a bored shaft, says the author, are smooth, circular, and not shattered by blasting so that lining is not required in most ground. Guides and columns can be directly fastened to the rock walls by stud bolts. The cage area is 79 per cent of the total shaft area. With a steel cage and guide the shaft is fireproof and free from timber maintenance charges. Better ventilation is insured because of smooth sides.

The drill used by the author is shown in cross section in Fig. 1 and was lowered into the drill hole on the end of a cable. It consisted of a cabin containing a motor, a driving mechanism and controls, and a seat for the operator. It could be securely fastened in place by six screw jacks forced against the side of the drill hole.

The 40-hp drive motor transmitted power through a chain

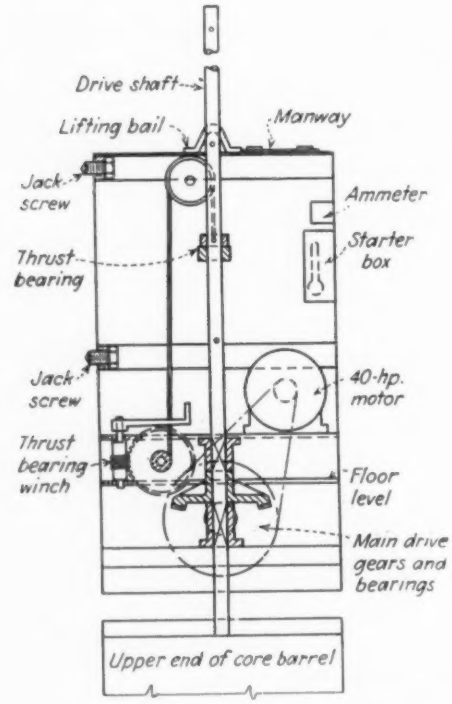


FIG. 1 GENERALIZED CROSS SECTION OF THE SHAFT DRILL

and conical gear to a vertical splined shaft extending through the center of the cabin. A movable thrust bearing was fixed on this splined shaft so that the operator, by means of a winch, could raise and lower the bearing and thus control the weight on the cutting screw. An ammeter indicated how much friction the drill was developing.

Attached to the lower end of the splined shaft was a core barrel 15 ft long equipped with detachable cutting shoes that were later replaced by a solid cutting ring. Fig. 2 shows a cross section of the completed shaft, cage, pipe lines, and conduits.

The drilling cycle was as follows: (1) Put the drill in the hole and line it up; (2) drill till the core is cut to its full depth; (3) remove the drill from the hole and set it back out of the way; (4) bail out the water and cuttings; (5) break off the core; (6) attach the core-hoisting tackle; (7) hoist and dump the core; (8) bail out the water and cuttings which were in the drill kerf during operation (4); and (9) inspect the bottom

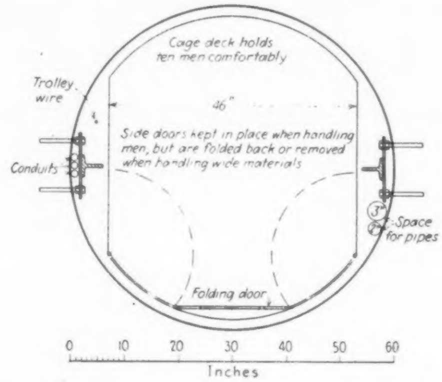


FIG. 2 CROSS SECTION OF THE COMPLETED SHAFT SHOWING CAGE OUTLINE, PIPE LINES, AND CONDUITS

of the hole and remove any broken pieces which would interfere with drilling the next core.

The combination core barrel and core puller not only cut the core, but also lifted it out of the hole.

The original article describes some of the experiences encountered in the use of the drill and in the technique of straightening the bore when it deviated from the true vertical. It is said that the best day's record was 10 ft per day and the best continuous record 21 ft in three days.

The following summary is of interest.

The method is inexpensive. When it is considered that a single man was used underground, that almost no powder was used, and that nearly 150 ft were sunk in a thirty-day period, the economy will be apparent.

In the hands of skilled operators, the method is safe. Inasmuch as powder is seldom used, rock is not hoisted over men, and the hoist lines are equipped with heavy safety hoods, the usual hazards of shaft sinking are greatly reduced. The record is a single broken leg and a few minor scratches.

Induced Scavenging

GAS AND OIL POWER

BY UTILIZING the properties of a wave motion in the exhaust pipe, a British manufacturer claims to have produced a two-cycle Diesel engine in which neither crankcase scavenging air pump nor scavenging blower is employed at normal running speeds for cylinder scavenging and charging. The principle employed is called "harmonic induction" by the makers of the engine, which is described in the December, 1936, issue of *Gas and Oil Power*.

The exhaust valve of the two-cycle engine is located in the cylinder head. When this valve opens, the sudden ejection of exhaust gases from the cylinder into the exhaust pipe sets up a wave motion in the pipe. Immediately following the initial compression wave formed by this sudden ejection is a

rarefication or partial vacuum completing the wave cycle. When this rarefication is transmitted into the cylinder and the inlet ports are opened at exactly the right moment, clean air from the atmosphere rushes into the cylinder. This correct timing depends on the proper length of the exhaust pipe. Once this length has been correctly fixed, exhaust and intake functions are properly timed.

In an editorial in the same issue it is said that a critic of the harmonic-induction principle would feel tempted to condemn it on the grounds that it would be insensitive in practice. This problem did confront the designers, and the bulk of the research work has been directed to making the principle operate efficiently over a comparatively wide range of engine speeds in single and multicylinder units. In a demonstration run, it was reported, a single-cylinder engine was started and operated with crankcase compression until it reached a speed where the induced-scavenging arrangements were effective. For this engine the harmonic-induction speed range was between 650 and 1100 rpm.

Color Control of Machine Tools

MACHINERY (LONDON)

MODERN machine tools are getting so complicated that for facility in operation the machinist is being provided with interlocking signals and significantly colored knobs on control levers in order to keep him from making mistakes. The development is known as "color control," certain applications of which are described by H. C. Town in *Machinery* (London) for Jan. 14, 1937.

One of these is a color scheme incorporated in boring and milling machines with the object of preventing faulty sequence of control by the operator. Two signal lights, red and green, indicate when the shaft of the saddle is running (red light) or stopped (green light). When the green light shows, change-gear levers are free, but when the shaft is running the levers are locked and a red light is showing.

In another instance, a colored-light diagram on the top of the control panel of a planing and milling machine by Schiess-Defries assists in the operation of the largest machine tool of this type. The machine is represented by a simplified diagram on a sheet of glass, Fig. 3, which shows the table, uprights, and tool slides. The object of the diagram is to enable the operators to see from their working position on the cross slide, what electrical connections are switched on or disengaged without the necessity of climbing ladders and going to the actual panel for verification. Briefly, if current is available the triangular symbols light up first. If green, the crossrail can be raised or lowered and the operating drives are interlocked, while red denotes that the crossrail is clamped to the uprights and the machine ready for working. As the crossrail is clamped, the interlock of the operating drives is disengaged, and the operator is made aware of this by the lighting up of other symbols in combination. The diagram also indicates by colors whether the table-traverse electrical control is set for planing or milling. When milling, the symbols on the heads 1 to 4, and when planing the symbols on the toolboxes I and II, are illuminated. Referring to the diagram, view *A* shows that the crossrail is free (green triangles). View *B* denotes by red triangles that the crossrail is clamped, the table is set for planing as shown by the red light denoting that the toolbox II is ready for service and box I with white light is out of operation. The remaining diagram indicates that the machine is changed over, for the milling heads 1 and 3, with red lights, are ready for operation, while 2 and 4, with white lights, are cut out.

On another machine, briefly described, various levers are provided with knobs of distinguishing colors to indicate their functions. Thus a red lever denotes start and stop; mottled orange, speed change; black and blue, a hand reverse motion; brown, locking; and green, feed change.

Another application of color control shown is a substitute for the familiar speed plate on lathe headstocks showing how levers should be set to obtain a given spindle speed. These instruction plates tend to become larger and hence great difficulty is presented in selecting the correct lever positions. This difficulty is removed by replacing the plates by a color-control drum indicator used in conjunction with colored handles, each bearing a symbol to indicate its operating position. The basis of the system is that of exposing a colored symbol on the drum indicating which particular lever is to be moved and at the same time showing the speed or feed resulting from such movement.

Applications of the color control-drum and a variation of it in the disk form are shown for a lathe, a boring machine, and a milling machine.

A Butterfly-Piston Pump

ENGINEERING

DIFFICULTIES experienced in dredging channels in marshy districts, where loose sand and waterweed interfere with the operation of pumps, led to the invention and patenting by Capt. Louis Le Clezio, of France, of a "butterfly-piston" reciprocating pump.

According to a brief description of the pump in the Nov. 13, 1936, issue of *Engineering*, the piston of this pump consists of a pair of semicircular flaps hinged on a crosshead at the end of a piston rod. On the forward stroke, as shown diagrammatically in Fig. 4, these flaps swing outward to form what is, in

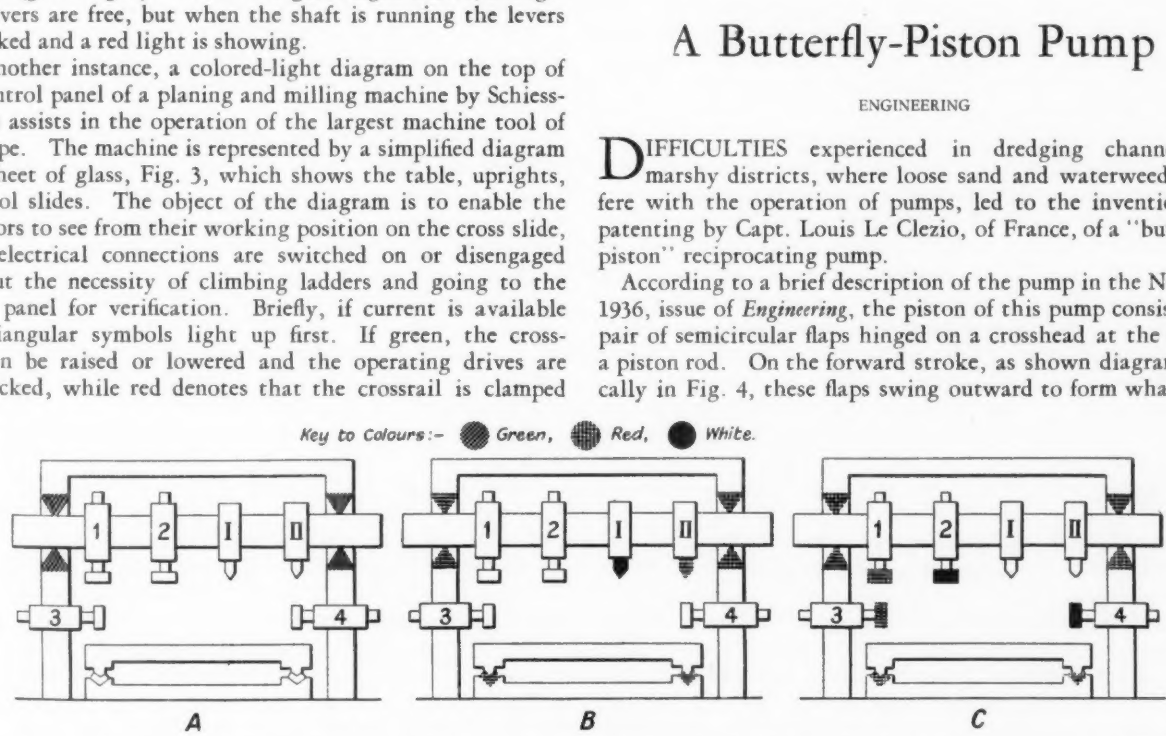


FIG. 3 COLORED-LIGHT DIAGRAM EMPLOYED TO FACILITATE THE CONTROL OF A LARGE PLANING AND MILLING MACHINE

effect, a solid piston in the pump barrel. The periphery of the flaps is prevented from actual contact with the pump walls by projections on the crosshead.

On the forward stroke, delivery on one side of the piston is, of course, accompanied by suction on the other. As the pump is single acting, the return stroke is an idle one, but there is no check in delivery because the momentum of the water keeps the flow always in one direction, the flaps closing together like a clam and offering little resistance. No foot valve is needed on the suction. The crosshead is usually made of mild steel and the flaps of duralumin. Stops prevent the flaps from injuring each other when they close.

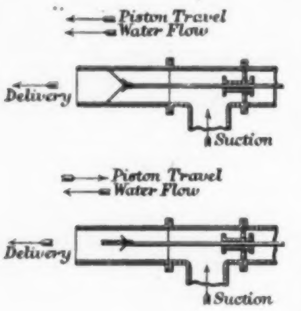


FIG. 4

A pump with a diameter of 100 m (3.93 in.) and a stroke of 130 mm (5.11 in.) driven by a 5-hp motor at speeds varying from 30 to 800 rpm gave a mean delivery of from 100 cu m (3531 cu ft) to 140 cu m (4943 cu ft) per min at a total head of 8 m (26.24 ft). This is a delivery between 2.5 and 3 times the theoretical displacement, accomplished by reason of the inertia effect.

Air Conditioning for Railroads

ASSOCIATION OF AMERICAN RAILROADS

ON OCTOBER 1, 1936, says the Summary Report on Air Conditioning of Railroad Passenger Cars, prepared by the Division of Equipment Research of the Association of American Railroads, there were 8031 air-conditioned passenger cars in the United States and Canada, of which 3907 were railroad-owned cars and 4142 Pullman-owned cars. The total investment in this air-conditioning equipment amounts to $45,000,000.

The investigation covered in the summary report was authorized to include (1) Survey of the performance of equipment in service, (2) determination of efficiency of air-conditioning systems, (3) determination of mechanical efficiency of drive mechanisms, (4) study of air requirements, treatment, diffusion, and related matters, (5) determination of cost of air conditioning per 1000 car-miles, and (6) study of factors relating to passenger comfort. The present report, which deals only with railroad-owned equipment, is to be followed by an engineering report, a report on performance of Pullman cars, and individual reports on their own equipment to the 31 railroads cooperating in the investigating.

In commenting on the economics of air conditioning following the presentation and discussion of test data the report states:

The fixed charges for an ice system are the lowest of all systems. During cooling seasons of three and five months, the fixed charges of the ice system influence the total cost more than does the cost of operation, hence the total cost for the ice system is the lowest. However, with a cooling season of eight or ten months, the cost of operation of the ice system influences the total cost more than do fixed charges. This being the case, the ice system becomes more expensive than the electromechanical. The fixed charges for the electromechanical system are less than all other systems, except ice. For this reason, the total cost of operation of the electromechanical system for cooling seasons of eight and ten months is the lowest of all the systems.

Discussion of the ice and electromechanical systems focuses attention upon the importance of the gross cost of installation. It is the gross cost of installation which must be reduced if a material reduction in the total cost per 1000 car-miles is to be accomplished.

It is recognized that in selecting an air-conditioning system other factors than cost must be considered, such as reliability, adequacy of results obtained, and terminal facilities. However, gross installation costs and total operating costs per 1000 car-miles are dependable units of measurement, and hence, due weight should be accorded them. This is especially true in the light of the large potential investment confronting the railroads through an increase in the number of cars to be air conditioned.

In considering the economics of air conditioning, it must be remembered that the overall cost, efficiency, and economy of any air-conditioning system may be markedly affected by the cost, efficiency, and economy factors associated with each element of the system. For instance, a given air-conditioning system may be composed of a combination of parts such that the gross installation cost, efficiency, and economy of the system will be all that could be expected. If a substitution is made for some part or parts that do not rank equally with those replaced, it may be found that the overall cost, efficiency, and economy are much less favorable than they were in the first case. This means that in selecting and purchasing an air-conditioning system the purchase price, efficiency, and economy of each part should be considered carefully. Otherwise, there may be no assurance of the merits and the reasonableness of the cost of the system selected and purchased.

On factors relating to passenger comfort observations are recorded of variations in 302 air-conditioned cars that were determined from data gathered by 20 railroads during regular service runs made from Aug. 1 to Sept. 15, 1936. This leads to a discussion of temperature and humidity control, filters, and odors.

The process of cooling cars, like that of heating, requires some form of temperature control. The optimum comfort in air-conditioned cars will not be attained until the control problem is solved. The solution of the problem will also contribute to a reduction in operating costs.

There are three general types of controls: Manual, semiautomatic, and automatic. The latter two are accomplished by various means. These will be discussed at length in the engineering report.

The manual type of control is highly unsatisfactory. If uniform and regular performance is desired, it should not be used.

The semiautomatic type is a marked improvement over the full manual, but the human element is associated with it. The elimination of this element is desirable.

The automatic types have not been perfected to the degree desired. Much development work is necessary.

There are those who feel that a form of modulated temperature control is needed. Such a type of control would automatically maintain within the car a temperature a predetermined number of degrees lower than the outside temperature. A successful control of this type would mark a real advance in air conditioning.

Temperature control is inseparably associated with humidity control. There is a diversity of opinion as to the need for humidity control. Most authorities agree that some type of humidity control is advisable.

An important advantage of air conditioning passenger cars

is cleanliness. This is, perhaps, as much appreciated by the traveling public as the lowered temperature. The cleaning is done by passing air through filters. These are, therefore, an essential element in an air-conditioning system. They are not only important from the viewpoint of cleanliness, but also with respect to odors.

The filter problem is indicated by the many different types being used. They are either dry or impregnated with oil of varying viscosity, and are made of: (1) Spun bronze wool, not coated; (2) series of wire screens of progressive decrease in mesh, oil coated; (3) metal shavings packed in a frame; (4) spun glass; (5) copper sprayed with oil; (6) impregnated hair; (7) oiled paper; (8) perforated cardboard coated with oil; and others. They range in price from 65 cents to $17.

The filter is too important an element with respect to cleanliness, odors, and operation costs to be neglected. There is a real need for a thorough and exhaustive study of the entire filter situation.

The problem of odors is universal. Some railroads have had reasonable success in reducing them. Odors result mainly from gas or smoke from the locomotive, tobacco smoke, body odors given off by passengers, improperly maintained toilets, refuse thrown on the floor by passengers, and from cooking and garbage in the dining cars. Odors are aggravated by humidity in excess of 60 per cent within the car and by an excessive use of disinfectant. Tobacco smoke, dust, and moisture produce a sour smell in the cooling coils if they are not cleaned often enough. Filters become impregnated with nicotine and grease, and odors result if they are not frequently cleaned or renewed. From the use of oil on the filters a gummy substance settles in the ducts which absorbs odors from cosmetics, tobacco, garbage, and other material.

Deodorants have been used with varying success. The use of ozone has been widely discussed as a purifying agent. Its value is doubtful.

Passenger comments are also summarized from cards returned to road engineers by 5453 passengers traveling on 20 railroads. The number of items on the card made it possible for the 5453 passengers to make 64,814 comments. Of this number only 4.4 per cent were unfavorable.

Metal Spraying

JOURNAL OF THE INSTITUTE OF METALS

SPRAYING of metals on other metallic surfaces for the purpose of building up worn parts or to provide a corrosion-resistant coating is accomplished by using a spraying pistol, in which the material to be sprayed may be in the form of a wire, a powder, or a molten mass, depending upon the type of pistol used. The processes in use today and the results of tests on some of the characteristics of the metal coatings formed are discussed by E. C. Rollason in the *Journal* of the Institute of Metals, Vol. 60, 1937.

With each type of pistol molten metal is sprayed by compressed air. The wire or powder, as the case may be, is melted in the pistol by means of a coal-gas or oxyacetylene flame, while in the molten-metal type the supply reservoir, about 4 lb capacity, is kept in a fluid condition by a bunsen flame. A table in the original article gives comparative details of the three types of pistols, all of which are described by the author. It is said that several electrically heated pistols have been patented but few have any commercial importance at the present time.

The author comments on the theory of metallizing as follows:

Schoop states that the atomized metal solidifies during flight owing to the cooling effect of the expanding air blast. When the particles strike the surface of the article their kinetic energy is transformed into heat with the result that they become momentarily plastic and weld together, but Arnold and Schenk have shown that the speeds necessary to produce the required amount of heat are in excess of any obtained in the process. In support of his theory Schoop points out that inflammable material can be sprayed, and shows that the temperature of the metal stream is only 60–70 C as measured by a thermometer. Thormann, however, has recently shown that the temperature of sprayed iron particles at a distance of 5 in. from the nozzle is 1000 C, and it is well known that if the pistol is directed to one area at a close distance the deposit can be melted. According to Schoop's theory cold powder could be sprayed to form a coherent coating, a process known to be unsuccessful.

A second theory, favored by Karg, Kutscher, and Reininger, assumes that cold solid particles of metal are hammered into the pores of the article by the great force behind them.

The hypothesis favored by Mr. Rollason is that the particles are melted completely or partially in the flame, depending on the spraying apparatus, and cool fairly slowly while traveling in the air stream, since there is little differential movement of the two materials. When the pistol is held close to the article (1 to 3 in.) the particles are still molten when they strike the surface. Splashes like fallen drops of solder are formed and interlock together. At high magnifications the microstructures of these splashes exhibit columnar crystallization, with discontinuous oxide films and cavities at the edges of the lamination; these crystals must have formed after the particles had struck the surface. After deposition, the particles are rapidly cooled by the air stream impinging against the surface, and since the base only conducts away a small proportion of the heat, an inflammable material is not ignited by the lower-melting-point metals sprayed normally. At greater distances from the nozzle the particles will be cooled below their freezing point, splashes will not form, but with sufficient kinetic energy the particles will be deformed into a laminated packing enclosing fine pores. At still greater distances the particles form a "heaped" sand-like mass with high porosity. This theory is substantially in agreement with that of Turner and Budgen.

The density of sprayed metal is always less than that of cast material and this is due partly to porosity and partly to oxide particles, the author points out. The porosity, consisting as it does of isolated cavities and interconnected pores, is difficult to estimate absolutely and no values are found in the literature. The interconnected pores allow liquids or gases to penetrate to the base metal, a disadvantage in certain applications. The author reports some attempts to estimate the interconnected porosity. From his experiments he concludes that at very small distances of the nozzles from the work the porosity is at a minimum. Unfortunately with nozzles of usual design, difficulties of operating at close distances are great. In practice wire-brushing is found to be successful in closing surface pores.

Zinc coatings afford excellent protection for iron and steel without danger of distortion, and are particularly useful for steel windows, light-gage sheet metal, springs, and nonmetallic articles. Zinc coatings afford an excellent base for paint.

Aluminum coatings are resistant to sulphurous atmospheres, and the very pure metal is gaining favor as a coating for the steel parts of aircraft.

Aluminizing is, of course, used to prevent scaling in furnace

equipment operating at high temperatures (up to 950 C) and to protect exhaust manifolds on aircraft.

Tin is used principally for coating food vessels.

Lead, nickel, copper, steel, and stainless-steel coatings all have their uses, the harder metals particularly for building up worn machine parts and for filling blowholes and cracks in castings where only compressive strength is required.

Among the more novel applications may be mentioned the treatment of insulators, radio apparatus, diathermic bandages, and wall paper, due to the conductive and electrical shielding properties of the coatings.

The author summarizes his conclusions by saying that it appears that each of the three types of metal-spray equipment has characteristic advantages which will allow all of them to survive competition and become useful tools in the engineer's hands.

Owing to its low costs, the powder process will undoubtedly prove successful in spraying large surfaces with zinc, especially when the coat is subsequently painted. This powder-spraying pistol also offers possibilities of spraying brittle metals and alloys of high melting point which could not be drawn into wire, although deposits of the higher-melting-point metals which have been examined are not wholly satisfactory as yet.

The molten-metal instrument can produce thick coatings of the low-melting-point metals at a reasonable price, and should prove useful to the galvanizer doing contract work, especially as the metal in ingot form is used and neither acetylene nor oxygen is required.

The wire pistol, on the other hand, will without doubt hold the field in building up thick deposits on worn articles and also for producing heat-resisting surfaces. Even in the production of zinc coating where the cost is higher than in the case of the other processes the wire pistol offers advantages in the spraying of internal work.

Streamlining in Britain

THE INSTITUTION OF MECHANICAL ENGINEERS

WITH reduced-scale models of L.M.S. and L.N.E. passenger rolling stock in a wind tunnel, a comprehensive study of air resistance of passenger trains has been carried out in Great Britain and the results have been reported in a paper by F. C. Johansen, engineering research officer, London, Midland and Scottish Railway, presented, on Nov. 27, 1936, before the Institution of Mechanical Engineers.

The main investigation reported relates to trains comprising a locomotive and six coaches, in which the aerodynamic forces on each vehicle were separately measured, the effect of train length on resistance of the last coach was determined, and hence the resistances of trains up to 12 coaches in length estimated.

Subsequent tests were made to determine the reductions of air resitance obtainable by rounding the front of the locomotive smokebox, covering the tender and the gaps between adjoining coaches, fairing the trailing end of the last coach, smoothing the coach bodies, and enclosing the undercarriages. The paper includes a brief analysis of the influence and worst direction of natural winds.

The fact that the paper contains 70 pages, 44 illustrations, and 12 tables makes a comprehensive abstract difficult in the space here provided. But the concluding portion of the paper, quoted in what follows, provides the following convenient summary.

(1) The air resistance of a train of conventional British type is equivalent to about $0.0016T^2$ lb per ton of train weight, where T is the speed in still air in miles per hour. This represents upward of half the total train resistance at speeds above 80 mph.

(2) The air resistance can be reduced by 50 per cent without drastic departure from conventional design, and by 75 per cent by ideal streamlining.

(3) The corresponding fuel economy is in the region of £1 per hour at train speeds of 100 mph. Alternatively, the maximum attainable speed can be increased by 12 to 25 per cent, according to the degree of streamlining adopted.

(4) Air resistance is augmented by side winds, the increase being mainly due to frontal pressure on exposed surfaces. The lateral wind force, perpendicular to the train, is large, but the consequent increase of forward resistance due to flange and bearing friction is relatively small, except for highly streamlined trains.

(5) The worst natural wind is not directly ahead but ranges from 30 to 60 deg on either side of the ahead direction.

(6) Streamlining measures are, on the whole, more effectual in side winds than in direct winds or in still air.

(7) The gaps between the coach bodies of an ordinary train account for relatively little air resistance, and much of it can be obviated by abutting coaches as close together as practicable and covering the remaining gap to the general contour of the train. The resistance is roughly proportional to the width of the gaps and arises far more from frontal pressure on the leading end of the "down-train" vehicle than from suction on the trailing end of the "up-train" vehicle.

(8) A surprisingly large proportion of the air resistance of a coach, especially under the action of oblique winds, is contributed by the trucks and undercarriage structure. It is consequently advantageous to use articulated stock, to include the undercarriages in streamlining measures, and to extend the fairings to the ends of the coaches, leaving no exposed gaps between them. The air resistance is less if the undercarriage is totally enclosed than if only side valances are fitted.

(9) A fair shape at the tail end of a train reduces air resistance to an extent which is more marked the more complete the streamlining, but greater advantage can be gained by fairing the front than by fairing the rear end.

(10) The air resistance of a conventional locomotive, amounting to 30 to 40 per cent of that of a complete six-coach train, can be reduced 25 per cent by rounding the smokebox front and covering the tender to the general contour of the train. An important advantage of the covered tender is in reducing the air resistance of the first coach.

(11) The streamlining of steam locomotives calls for aerodynamic study of the machine as a whole, attention being paid simultaneously to air resistance, the deflection of the exhaust away from the driver's vision, the access of air to the fire grate and bearings, and the design from the standpoints of accessibility and operating convenience.

(12) The full benefit of measures to reduce air resistance can be realized only if the locomotive and the coaches are all streamlined. The air resistance of coaches may be less if they are drawn by a conventional rather than by a streamlined locomotive, though not to such an extent as to outweigh the advantage of streamlining the locomotive. Trains of set composition offer an advantage in respect of complete streamlining.

(13) The ideal streamlined train is a continuous cylindrical body with well-rounded ends, having a polished surface free from external fittings and irregularities. A tubular structure, incorporating a stressed skin of sheet metal suggests itself for coach construction along these lines.

LETTERS *and* COMMENT

Performance of Oil Rings

To the Editor:

The superior performance of the new design with grooves is clearly demonstrated in this paper.[1] Another type with reduced contact area designed about twenty years ago by one of the leading manufacturers of electric motors provides a contact surface only $^1/_{16}$ of an inch wide on a 1-inch ring of large diameter. It is said that rings have also been used in which the contact surface is knurled. Can the authors supply any information as to the comparative performance of these various types?

Figs. 6 and 7 of the paper showing gallons per minute of oil delivered as a function of speed are of particular interest. It would be of value to learn in more detail how the authors decided upon the arrangements for collecting the oil and how closely the delivery rate measured in this way agrees with the actual delivery to the journal.

Have empirical formulas been considered for expressing the quantity of oil Q, delivered per unit of time as a function of the speed of the shaft N, the ring diameter D, oil viscosity Z, and other variables? Such formulas or curves built up from the present available data, might be useful in predicting the probable delivery for geometrically similar rings of different sizes.

In Fig. 6 for the ring of diameter $D = 15$ inches, the journal diameter is $d = 9$ inches, and the height of immersion $H = 1$ inch, therefore $d/D = 9/15 = 3/5$ and $H/D = 1/15$. In Fig. 7, for the larger ring, $D = 30$ inches, while $d/D = 2/3$ and $H/D = 1/12$. One ring has three grooves, the other four. Thus the two systems are nearly but not quite geometrically similar. Under suitable conditions one experiment might be almost dynamically similar to the other; so that the performance of the larger ring could be estimated from tests on the smaller ring treated as a model.

The following relations obtained by dimensional analysis may be of interest, and are applicable to geometrically similar systems with a constant ratio of ring density ρ_0 to oil density ρ. For brass rings this ratio may be taken approximately equal to 9.5. We begin by assuming that, under the foregoing conditions, the delivery rate Q depends only upon the following six physical quantities:

D = inside diameter of the ring
N = journal speed in revolutions per unit time
Z = effective viscosity of the oil
S = surface tension in air
ρ = density of the oil
G = weight of oil per unit volume or product of density by acceleration of gravity, ρg.

The foregoing assumption is equivalent to the statement that

$$Q = f(D, N, Z, S, \rho, G) \quad \ldots\ldots [1]$$

where f is some function that remains to be discovered.

From Buckingham's theorem[2] the number of independent dimensionless products that can be formed out of the 7 physical quantities in Equation [1] will be $i = 7 - 3 = 4$. These may be designated arbitrarily by the symbols q, u, v, w and written down (by trial or otherwise) in the form

$$\left.\begin{aligned} q &= Q/D^3N, \\ u &= \rho ND^2/Z, \\ v &= ZND/S, \\ w &= GD/ZN. \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots [2]$$

Hence the general solution may be expressed

$$q = \phi(u, v, w) \quad \ldots\ldots\ldots [3]$$

where ϕ is another unknown function; but in which the number of independent variables has been reduced from six to three.

The conditions for dynamical similarity are that $u = u_0$, $v = v_0$, and $w = w_0$ where symbols with subscripts refer to the original, other symbols to the model. When these conditions are satisfied, $q = q_0$ or

$$\frac{Q}{Q_0} = \left(\frac{D}{D_0}\right)^3 \frac{N}{N_0} \quad \ldots\ldots\ldots [4]$$

At very low speeds the effects of density and surface tension may be small compared to those of gravity and viscosity, in which event u and v can be dropped out leaving as a first approximation

$$q = \phi_1(w) \quad \ldots\ldots\ldots\ldots [5]$$

or

$$Q = ND^3\phi_1\left(\frac{ZN}{GD}\right) \quad \ldots\ldots [6]$$

Thus if an experiment in which the speed alone is varied showed that

$$Q = CN^n \quad \ldots\ldots\ldots\ldots [7]$$

in which C and n are numerical constants, we could infer by combining Equations [6] and [7] that

$$Q = CN^nD^{4-n}\left(\frac{Z}{G}\right)^{n-1} \quad \ldots\ldots [8]$$

At the other extreme (very high speeds), gravity and surface tension may be negligible compared to the viscous and inertia forces, hence for quite high values of u we might anticipate that v and w would drop out, leaving to a first approximation

$$q = \phi_2(u) \quad \ldots\ldots\ldots\ldots [9]$$

or

$$Q = ND^3\phi_2\left(\frac{\rho ND^2}{Z}\right) \quad \ldots\ldots [10]$$

If experiment showed $q = Cu^n$ we should infer from Equation [10] that over the observed range of u, v, and w

$$Q = C\rho^n\ N^{n+1}D^{2n+3}Z^{-n} \quad \ldots\ldots [11]$$

From the data corresponding to Figs. 6 and 7 of the authors' paper it is found that $n = -0.88$ while $C\rho^n = 0.0059$ provided Q is measured in cubic inches per second, N in revolutions per second, D in inches, and Z in centipoises. This relation is limited to values of ND^2/Z greater than 300 square inches per centipoise second. Expressing Q in U. S. gallons per minute and N in revolutions per minute while taking D in inches and Z in centipoises

$$Z = 0.00094N^{0.12}D^{1.24}Z^{0.88} \quad \ldots [12]$$

the specific gravity of the oil remaining the same as in the experiments. Equation [12] may be remembered more easily in the approximate form: Gallons per minute = $N^{0.1}D^{1.2}Z^{0.9}$ divided by 1000.

This result expresses mathematically the fact that oil rings are relatively less efficient at the higher speeds and temperatures (high values of ND^2/Z), since under these conditions a considerable increase of speed is accompanied only by a very slight increase in the rate of oil delivery.

Mayo D. Hersey.[3]

[1] "Performance of Oil Rings," by R. Baudry and L. M. Tichvinsky, Mechanical Engineering, vol. 59, February, 1937, pp. 89–92.

[2] "Model Experiments and the Forms of Empirical Equations," by E. Buckingham, Trans. A.S.M.E., vol. 37, 1915, pp. 263–296. Also: "Theory of Lubrication," by M. D. Hersey, John Wiley and Sons, Inc., New York, N. Y., 1936, chapter IV.

[3] Kingsbury Machine Works, Inc., Philadelphia, Pa. Mem. A.S.M.E.

TO THE EDITOR:

M. D. Hersey has given an interesting application of dimensional analysis to a rather complicated problem. The authors will try to apply this method to the analysis of tests made on geometrically similar oil rings.

The authors believe that the performance of a ring having only a narrow contact surface at the center will be the same as that of the relieved ring, the performance of which is given in Fig. 2 of the paper. This type of ring works in the region of solid friction up to a higher speed than the smooth or grooved ring. There is a small region where it delivers more oil than the smooth ring. In the region of fluid friction, which is the normal range of operation for the oil rings used on most high-speed bearings, the ring with a narrow contact surface will be inferior to the smooth or grooved oil ring.

Oil rings with knurled surfaces have not been tested by the authors. They would probably deliver a still larger amount of oil than the rings tested. For steady operation at high speed it is believed that the oil rings should have machined teeth, like those of a gear. This design was considered by the authors but the machining was found to be too expensive. The value of the grooved oil ring is that it produces a large increase in oil supply at a very small additional cost.

L. M. TICHVINSKY.[4]
R. BAUDRY.[4]

[4] Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of January 29, 1937, and approved by the Council.

CASE No. 837

(*Special Ruling*)

Inquiry: May unfired pressure vessels to be stamped as Code vessels be built in whole or in part of cast iron (other than nozzles and frames for openings now definitely provided for)?

Reply: It is the opinion of the Committee that under a correlation of the several sections of the Code, unfired pressure vessels of any size may be built wholly or in part of cast iron, subject to the following restrictions:

(1) Vapor (steam) pressure shall not exceed 15 lb per sq in.

(2) Liquid (water) pressure shall not exceed 160 lb per sq in., nor the temperature 250 F.

(3) Cast-iron pressure parts conforming to the requirements of the several A.S.A. standards for cast-iron fittings may be used as a whole or in part for temperatures not exceeding 450 F and pressures not exceeding the A.S.A. ratings given in the several tables.

(4) All such cast-iron vessels or cast-iron parts shall be inspected and given a hydrostatic test in the presence of an authorized inspector, the test to be at least equal to $2^1/_2$ times the maximum allowable working pressure but in no case less than 60 lb.

(5) Following the hydrostatic test, the vessel may be stamped as required by Par. U-66 and data sheets made out as required by Par. U-65.

CASE No. 839

(In the hands of the Committee)

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

Specification S-5. To make this specification identical with A.S.T.M. Specification A 31-36, Par. 2 will be revised by increasing the sulphur content from "0.045" to "0.05" per cent.

Specification S-7. To make this specification identical with A.S.T.M. Specification A 107-36, revise the table in Par. 10 to read:

Diameter, in.		Variation in diameter, in.		
Over	To and including	Under	Over	Out of round
...	$^5/_{16}$	0.007	0.007	0.010
$^5/_{16}$	$^7/_{16}$	0.007	0.007	0.011
$^7/_{16}$	$^5/_8$	0.008	0.008	0.012
$^5/_8$	$^7/_8$	0.009	0.009	0.014
$^7/_8$	1	0.010	0.010	0.015
1	$1^1/_8$	0.012	0.012	0.016
$1^1/_8$	$1^1/_4$	0.014	0.014	0.018
$1^1/_4$	$1^3/_8$	0.016	0.016	0.022
$1^3/_8$	$1^1/_2$	0.018	0.018	0.026
$1^1/_2$	2	0.022	0.022	0.030
2	$2^1/_2$	0	$^1/_{16}$	$^1/_{32}$
$2^1/_2$	$3^1/_2$	0	$^5/_{64}$	$^3/_{64}$

Specification S-13. This specification will be completely revised. It will be based on A.S.T.M. Specification A 48-36. Copies of the revised form are available upon application to the Secretary of the Boiler Code Committee.

Specification S-17. To make this specification identical with A.S.T.M. Specification A 83-36, Tables 1 and 2 covering the standard weights of tubes, Par. 17*b*, and the footnote of Table 3 will be revised.

Specification S-18. To make this specification identical with A.S.T.M. Specification A 53-36, Pars. 1 and 5 will be revised.

Specifications S-33, S-34, and S-35. These specifications will be revised to make them identical with A.S.T.M. Specifications A 157-36, A 158-36, and A 182-36.

Specification S-36. This new specification will be identical with A.S.T.M. Specification

B 96-36T on Specifications for Copper-Silicon Alloy Plates and Sheets.

Specification S-37. This new specification will be identical with A.S.T.M. Specification B 97-36T on Specifications for Sheet Copper-Silicon Alloy.

Specification S-38. This new specification will be identical with A.S.T.M. Specification B 98-36T on Specifications for Copper-Silicon Alloy Rods, Bars, and Shapes.

PAR. H-21. Add the following:

In the construction of steel-plate, low-pressure heating boilers to be operated at 15 lb steam and 30 lb water and having welded joints, the allowable distance from a corner welded joint to the nearest row of staybolts may be a full pitch as provided by the formula in this paragraph. This does not, however, apply to a welded joint in a flat surface where the spacing is limited to one half of a full pitch.

PAR. H-65. Revised to read:

H-65. All hot-water HEATING AND HOT-WATER SUPPLY boilers STAMPED FOR [the maximum allowable] working pressures [of which is] not OVER [in excess of] 40 [30] lb per sq in., and steam-heating boilers shall be subjected to a hydrostatic test of 60 lb per sq in. at the shop where constructed. Hot-water HEATING AND HOT-WATER SUPPLY boilers STAMPED FOR [the maximum allowable] working pressures [of which exceeds] OVER 40 [30] lb per sq in., shall be subjected to a hydrostatic test of 1 1/2 times the maximum allowable working pressure both at the shop where constructed and in the field when erected and ready for service.

Any hydrostatic pressure test to be made on either a steam-heating boiler or hot-water boiler, after the boiler has been in service, shall be at a pressure of 1 1/2 times the maximum allowable working pressure.

In making hydrostatic pressure tests the pressure shall be under such control that in no case shall the required test pressure be exceeded by more than 10 LB PER SQ IN. [6 per cent].

PAR. H-118. Revise to read:

H-118. All hot-water HEATING OR HOT-WATER SUPPLY boilers MARKED FOR [the maximum allowable] working pressures [of which is] not OVER [in excess of] 30 lb per sq in., and steam-heating boilers shall be subjected to a hydrostatic test of 60 lb per sq in. at the shop where made, on each individual section. Hot-water HEATING AND HOT-WATER SUPPLY boilers MARKED FOR [the maximum allowable] working pressures [of which exceeds] OVER 30 lb per sq in., shall be subjected to a hydrostatic test of 2 1/2 times the maximum allowable working pressure both at the shop where made, on each individual section, and in the field when erected and ready for service.

Any hydrostatic pressure test to be made on either a steam-heating boiler or hot-water boiler, after the boiler has been in service, shall be at a pressure of 1 1/2 times the maximum allowable working pressure.

In making hydrostatic pressure tests the pressure shall be under such control that in no case shall the required test pressure be exceeded by more than 10 LB PER SQ IN. [6 per cent].

PAR. H-70. Add the following:

In determining the pitch of staybolts, fusion-welded joints may be considered as fully supported except where the joint occurs in a flat surface.

PAR. U-66*a*. Revise the first sentence as follows:

a Each such pressure vessel shall CONFORM IN EVERY DETAIL TO THESE RULES AND SHALL be DISTINCTLY stamped in the presence of the inspector with the symbol as shown in Fig. U-7, the manufacturer's name, the manufacturer's serial number, the working pressure and the year built, DENOTING THAT THE VESSEL WAS CONSTRUCTED IN ACCORDANCE THEREWITH.

TABLE P-5 REVISED:

TABLE P-5 MAXIMUM ALLOWABLE WORKING PRESSURES FOR STEEL OR WROUGHT-IRON TUBES OR FLUES FOR FIRE-TUBE BOILERS, FOR DIFFERENT DIAMETERS AND GAGES OF TUBES, CONFORMING TO THE REQUIREMENTS OF SPECIFICATIONS S-17 OR S-32

	Minimum gage, Bwg									
Outside diam. tube, in., D	13 $t =$ 0.095	12 $t =$ 0.109	11 $t =$ 0.120	10 $t =$ 0.134	9 $t =$ 0.148	8 $t =$ 0.165	7 $t =$ 0.180	6 $t =$ 0.203	5 $t =$ 0.220	4 $t =$ 0.238
1	420	620	770	970	...	...	...	...	...	...
1 1/2	280	410	520	650	780	940	...	...	...	...
1 3/4	240	360	440	560	670	800	920	1110	1240	1390
2	210	310	390	490	590	700	810	970	1090	1210
2 1/4	190	280	350	430	520	630	720	860	970	1080
2 1/2	170	250	310	390	470	560	650	780	870	970
3	...	210	260	330	390	470	540	650	730	810
3 1/4	...	190	240	300	360	430	500	600	670	750
3 1/2	...	180	220	280	340	400	460	560	620	700
4	...	...	200	250	290	350	410	490	550	610
4 1/2	...	...	180	220	260	320	360	430	490	540
5	...	...	...	190	240	280	330	390	440	490
5 3/8	...	...	...	...	210	260	300	360	410	450
5 1/2	...	...	...	...	190	250	300	360	400	440
6	...	...	...	...	...	200	250	320	370	410

$$P = \frac{(t - 0.065)}{D}\,14{,}000$$

where P = maximum allowable working pressure, lb per sq in., t = minimum wall thickness, in. and D = outside diameter of tubes, in.

For pressures below those given in the table, the gage thickness shall not be less than the minimum given in the table.

TABLE L-2 REVISED:

TABLE L-2 MAXIMUM ALLOWABLE WORKING PRESSURE FOR STEEL OR WROUGHT-IRON TUBES OR FLUES FOR FIRE-TUBE BOILERS, FOR DIFFERENT DIAMETERS AND GAGES OF TUBES, CONFORMING TO THE REQUIREMENTS OF SPECIFICATIONS S-17 OR S-32

	Minimum gage, Bwg									
Outside diam. tube, in., D	13 $t =$ 0.095	12 $t =$ 0.109	11 $t =$ 0.120	10 $t =$ 0.134	9 $t =$ 0.148	8 $t =$ 0.165	7 $t =$ 0.180	6 $t =$ 0.203	5 $t =$ 0.220	4 $t =$ 0.238
1	470	690	860	...	...	...	...	...	...	...
1 1/2	320	460	570	720	860	...	...	...	...	...
1 3/4	270	400	490	620	740	890	...	...	...	...
2	240	350	430	540	650	780	900	...	...	...
2 1/4	210	310	380	480	580	690	800	960	...	...
2 1/2	190	280	350	430	520	630	720	860	970	1080
3	160	230	290	360	430	520	600	720	810	900
3 1/4	...	210	270	330	400	480	550	660	750	830
3 1/2	...	200	250	310	370	450	520	620	690	770
4	...	180	220	270	330	390	450	540	610	680
4 1/2	...	160	190	240	290	350	400	480	540	600
5	...	...	180	220	260	320	360	430	490	540
5 3/8	...	...	160	200	240	290	340	400	450	500
5 1/2	...	...	...	200	240	290	330	390	440	490
6	...	...	...	180	220	260	300	360	410	450

$$P = \frac{(t - 0.065)}{D}\,15{,}550$$

where P = maximum allowable working pressure, lb per sq in., t = minimum wall thickness, in., and D = outside diameter of tubes, in.

For pressures below those given in the table, the gage thickness shall not be less than the minimum given in the table.

AUTHORS *and* PAPERS

CORRECTION

LAST month, with a frailty that we hope is human, we gave on our contents page an incorrect description of the cover picture. Fortunately, perhaps, the error was too obvious to misguide engineers, for even the least informed can tell a metal-cutting operation from external centerless grinding. Apologies are humbly offered. On some future cover the centerless-grinding picture will be displayed.

This error was sufficiently stupid and exasperating, but it was like rubbing salt in open wounds to have Dr. Giesl call our attention to the fact that, in the second line of page 164, the availability of the original *Zephyrs* was given as 9 per cent instead of 97 per cent.

GRINDING CEMENTED CARBIDE

With the increased use of cemented carbide in metal-cutting tools have come problems in grinding technique not encountered with high-speed steel cutters. As an aid in the solution of some of these problems, HANS ERNST and MAX KRONENBERG, of the Cincinnati Milling Machine Company, have prepared a paper entitled "Grinding of Cemented-Carbide Milling Cutters," to be found on page 221. The paper is scheduled for presentation in May at Detroit, at the 1937 Semi-Annual Meeting of The American Society of Mechanical Engineers.

Mr. Ernst, who, for the last eleven years has been in charge of research and development for his present employers, was born and educated in Australia, and came to this country in 1915. He is a member of the A.S.M.E. and serves on its subcommittee on metal-cutting materials. Mr. Kronenberg, engineer in the research department of the same company, is a native of Germany, where he was active in consulting and research with the machine-tool industry. His connection with his present employers began in July, 1936. He was formerly chairman of the V.D.I. subcommittee on production and a member of the German Standardization Committee on Tools.

WHY CHOOSE THE AUTOMOBILE INDUSTRY?

C. J. FREUND, who is a member of the A.S.M.E. Committee on Education and Training for the Industries and dean of the College of Engineering, University of Detroit, is interested in providing young engineers with specific and authentic information on what the various typical engineering industries in the country have in store for them. To find this out with respect to the automobile industry, he asked questions of a number of executives and has tabulated their answers and commented on them in a paper entitled, "The Automobile Industry and Young Engineers," page 227.

The questions Dean Freund asked referred to such factors as the relative value of several elements of engineering work in this industry, qualifications required of automotive engineers, how to get into the industry, opportunities for advancement, what college studies are most valuable, and what the prospects are of the future. Inasmuch as Dean Freund's paper is to be presented and discussed in Detroit in May, interest in it is particularly timely.

Dean Freund's work, prior to that in which he is at present engaged, was in vocational training in the metal trades of Milwaukee and the Falk Company. He is a frequent contributor to MECHANICAL ENGINEERING on subjects relating to engineering education and vocational training.

MARKET RESEARCH

Market research is one of those look-before-you-leap applications of engineering principles that has provided opportunity for engineers in industry. By tempering the enthusiasm of the promoter with coldly reasoned facts, industrialists can size up the market possibilities of a proposed product, locate the best prospects of customers for it, find out what the purchasers want and what features they consider desirable, what is the best approach through advertising, and what advertising media will prove most successful when the product is put on the market.

These are some of the ways in which market research aids industrial sales promotion, as brought out by E. J. KLOCK in a paper, page 230, on that subject. Mr. Klock is in charge of the market-research division of the General Electric Company, Schenectady, N. Y. He has been associated with that company since 1925, when he completed a course at the Harvard Graduate School of Business Administration. Mr. Klock has also assisted in developing a new and improved sales record system for the General Electric Company and in the study and selection of advertising media most suitable for reaching various markets. In 1927 he received the National Industrial Advertising Association research award for the best industrial-market survey submitted.

A 270-TON GANTRY CRANE

In contrast to the mass-production industries that engage the attention of so many mechanical engineers are the engineering firms that design and build structures such as the gantry crane for Wheeler Dam, described in this issue, page 231, by M. R. BOWERMAN, of the Alliance Machine Co., Alliance, Ohio. Specifications for this 270-ton electric gantry crane were prepared by the Bureau of Reclamation and the Tennessee Valley Authority and the crane was built at Alliance.

Mr. Bowerman, who is a member of the A.S.M.E., was graduated from Michigan State College in 1909. Since graduation he has been engaged in engineering work, chiefly in connection with iron-works companies, and in teaching applied mechanics and machine design. For his present employers Mr. Bowerman has been engaged in engineering work on electric traveling cranes and special machinery.

RAILWAY LUBRICANTS

Because the lubrication problems of the railroads include almost every type of lubrication known and because there are available for use almost every lubricant offered for sale, the railroad lubrication engineer must have a thoroughgoing knowledge of requirements and oil characteristics if he is to perform his duties intelligently and satisfactorily. Hence the paper on "Railway Lubricants," page 235, by B. F. HUNTER, of the Gulf Oil Corporation, Pittsburgh, Pa., with its comments on the possibilities of standardization, will interest lubrication engineers of the railroads as well as those employed by the oil companies.

Cooperation between railroad and manufacturer has resulted in a greater amount of the common knowledge of important problems held by both, and constant contact and study are fruitful of further progress, says Mr. Hunter. Continued development and progress demand even closer cooperation.

Mr. Hunter, who had a rich and varied engineering career prior to 1919 when he became chief lubrication engineer for the western division of the Texas Company, associated himself with the Gulf Oil Corporation and Gulf Refining Company in that same capacity in 1925.

STEAM-TURBINE HISTORY

Previous issues of MECHANICAL ENGINEERING have presented historical sketches of the development of the steam turbine in the United States by the Westinghouse and Allis-Chalmers companies. The third of this series, page 239, is by ERNEST L. ROBINSON, and describes the development of the General Electric steam turbine, which began in 1897 with an agreement with the inventor for the exploitation of the Curtis turbine. Mr. Robinson follows through the principal stages of this development with brief comment on the parts played by those responsible for them.

Mr. Robinson, a member of the A.S.M.E., and engineer in the turbine-engineering department of the General Electric Company, Schenectady, N. Y., holds degrees from St. Lawrence and Harvard universities. He had a varied engineering experience before the War, and his engagement by the General Electric Company in 1919 is touched upon in his paper.

STATISTICS IN CONTROL OF QUALITY

Readers of MECHANICAL ENGINEERING will recall a series of abstracts of papers on quality control presented at the 1935 Semi-Annual Meeting held in Cincinnati. One of the striking features of these papers was the evidence they presented of the practicability of using statistical technique in attacking problems of quality control. Although this technique is relatively new in mechanical engineering, the potentiality of its wide application was evident from a reading of the papers.

On page 261 of the present issue HAROLD A.

FREEMAN, who is a member of the department of economics of the Massachusetts Institute of Technology, reviews two books on the general subject of the statistical method as applied to quality control and indicates its growing importance in industry by his mention of courses in the subjects that are now offered at the Institute.

GEORGE WESTINGHOUSE

Engineers who attended the 1936 Annual Meeting of the American Society of Mechanical Engineers will remember with satisfaction the commemorative exercises held on Tuesday afternoon at which a number of former associates of George Westinghouse paid personal tribute to his engineering achievements by describing some of their experiences with him. The exercises, which were arranged by Chas. F. Scott, had been carefully prepared to give the impression that a gathering of former friends had met in whose minds Professor Scott's queries evoked old memories. Then "script" used on this occasion has the historical value of eye-witness testimony and is published this month, page 263, with a number of the illustrations that were used during the exercises. It was a moving tribute to a world-famous American engineer who was an honorary member, and at one time, president, of The American Society of Mechanical Engineers.

REVIEWS *of* BOOKS

Industrial Design and Art

ART AND THE MACHINE. An Account of Industrial Design in Twentieth-Century America. By Sheldon Cheney and Martha Candler Cheney. Whittlesey House, McGraw-Hill Book Company, New York, 1936. Cloth, 7×9 in., 307 pp., illustrations, bibliography, $3.75.

REVIEWED BY I. N. LIPHSHITZ[1]

WHEN Norman Bel Geddes published his volume "Horizons" in 1932, depicting the future in industrial design, the world gasped. Here was one of the foremost industrial designers proposing for actual design and use, products and equipment which seemed like illustrations from an H. G. Wells or Jules Verne novel. Since then the movement in industrial design has developed rapidly both in consumers' products and in capital-goods equipment. Already we look at the radically altered form of the automobile, the refrigerator, the kitchen stove, the bathroom fixture with an air of ease and familiarity. The product of several years back seems ages old. Our bottles, glassware, kitchenware, knives, wrappers, everyday equipment have been so radically but so consistently altered, that we are startled to find the vast difference that exists between a present-day product and its forbear of only three or four years back.

In the capital-goods field this same trend toward complete industrial redesign can be discerned, producing equipment with a simpler, smoother, cleaner, more pleasing, and technically more perfect, form. Our streamlined railroad locomotive, the majestic beauty of the newer giant ocean liners, the sleek, suggestive beauty of the modern airplane or automobile, the simple, rugged and power structure of a modern machine tool, the quiet, bright and beautiful simplicity of the newer architecture, these are all manifestations of the same trend in industrial redesign.

The aesthetic as well as the technical possibilities inherent in machine production due to improved methods, newer materials (the plastics, light metals, alloys, etc.), improved surface finishes, have to some extent been realized and are being consciously developed. The now familiar industrial art exhibits have familiarized the public with these advances and sponsor further progress in the field.

The names of the leading industrial designers have become widely known. Norman Bel Geddes, Walter Dorwin Teague, Henry Dreyfuss, George Sakier, Raymond Loewy, Otto Kuhler, Joseph Sinel, Harold Van Doren, Donald Deskey, Gilbert Rohde, Russell Wright, Lurelle Guild, Donald Dohner, and the young Montgomery Ferar are figures whose designs which "range from a lipstick to a steamship, from a paper clip to a locomotive, from an ash tray to a model industrial community" have become parts of our daily lives. The architects, Lescaze, Kiesler, and Neutra, practicing as industrial designers, are well-known figures.

Yet, in the Cheneys' book for the first time in this country, is there presented a broad integrated treatment of this movement. British writers and critics including Holme, Read, and Gloag, whose excellent little book "Industrial Art Explained" has been omitted from the bibliography, have given us previous histories and discussions of the industrial-design field.

"It is the purpose of this book," the Cheneys inform us, "to offer an aesthetic canon for industrial design, to show:

1 That American engineering was one of the two streams of influence that flowed together to produce industrial design, abstract art the other.

2 That the industrial designer's product (as now familiar to every one in a wide range of everyday commodities) is a twentieth-century craftsmanship as valid for useful objects of our age as was the fine handicraft that prevailed in the furnishings and accessories of late seventeenth-century England.

3 That industrial design is part of a wider three-dimensional expression now apparent in many fields, representing everywhere the work of the artist-technologist; the product everywhere of the same principles, with the same style marks.

In the nineteenth century, art was something to be added to the machine, not derived from it. New machines were frilled and ornamented. Steam engines were decorated with "period" columns, machine tools with elaborate decorative grillwork. Glass of beautiful shape was "tortured with ornament." Even today we see metal stampings of excellent form which are afterward gaudily embossed. The brilliant aesthetic possibilities inherent in machine production were not realized. There was, and still is to some extent, the authors point out, "much confusion everywhere between old, two-dimensional applied design and new built in, three-dimensional design—between appearance design that is decoration and appearance design that is engineering."

Not that the possibilities were altogether unrealized. As early as 1864, James Jackson Jarvis noted:

> The American while adhering closely to his utilitarian and economical principles, has unwittingly, in some objects to which his heart equally with his hand has been devoted, developed a degree of beauty in them that no other nation equals. His clipper-ships, fire-engines, locomotives, and some of his machinery and tools combine that equilibrium of lines, proportions, and masses, which is among the fundamental causes of abstract beauty.

There was, however, no conscious striving after beauty in machine commodities. The tempo of industrialization was too rapid, the purely technical problems too great. It was only after the mastery of technical problems that industry was given leeway to redesign with emphasis on form and beauty. The gradual refinement which had been going on for many years took on an accelerated development and assumed the character almost of a revolution.

The artist who had previously despised industry and machine production

[1] New York City, Jun. A.S.M.E.

saw that the engineer had developed certain new forms of beauty and created the possibilities of new artistic standards. He turned functionalist stating now that "form follows function," everything that is functionally correct is also artistically correct. From this extreme, necessary perhaps to break from his early attitude of despising the machine, the artist gradually realized, and with him the engineer and industrialist, that in the unity of engineering and art, in the integration of the technical and artistic values, lay the possibilities of the new aesthetic, the new culture.

There was an early period when the industrial designers distrusted the manufacturers and vice versa. The early designers were not well equipped to solve industry's problems. Some of them previously were artists, others were engineers with artistic talents. But the tasks of solving technical and appearance problems together were many and unprecedented. It took quite a long time to evolve methods to tackle this work, to develop industrial design as a profession.

The service which modern industrial designers render to industry is varied. Some design an entire line of products, others serve as consulting designers working in cooperation with the manufacturers' style or design departments, and some serve as almost complete product-engineering units. Walter Dorwin Teague, for example:

has prepared for his clients an "Outline of Industrial Design" worthy to serve as a terse and businesslike model of the designer's service, its aims, methods, and results. The service is summarized as "the organization of a manufactured product to increase its desirability, and hence its sales." The aims are: (1) improved appearance; (2) improved serviceability; and (3) increased economy. He lists the methods, which cover study of operating, structural, and production requirements, and marketing problems (including the problem of competition). The steps in "design creation," as outlined, lead from preliminary sketch to completed model; and characteristically are extended to cover assistance in marketing, including such services as talks to sales forces, and publicity.

The industrial-design movement is here to stay. It is a definite progressive stage in the development of techniques. Already many of the major industries (e.g., automobile, electrical) have their own permanent design departments. The problem now becomes how to train and develop new designers with the necessary qualities to serve modern industry. They must be artist-technologists in the true sense of the term. They must have thorough training and ability in art, a keen appreciation of form, structure, color, texture, finish, as well as a thorough training in engineering, a knowledge of modern materials and their structural possibilities, of machine operations, of production methods and processes, of standardization and tooling problems. Add to this their necessary knowledge of consumer demands and trends in industry generally, and we see that the training of a modern industrial designer is no small task.

How is the modern school or university to meet this task? This is a problem which is at present being worked out. The Cheneys believe that: "A proper school will serve to bring the student's ability to focus at the center of the complex which includes artist, industrialist, and consumer; studio, factory, and store."

There was a time when some feared that the engineer with his machine industry would bring ugliness into the world, but this new alliance of art and industry, this new possibility which advancing industry has given modern life is strikingly brought out by the development of the industrial-art movement. How engineers and progressive manufacturers view this movement can be seen from the remarks of John W. Higgins, President of the Worcester Pressed Steel Company, who has correctly said:

Manufacturers must be realists and must give their first attention to techniques, mechanics, and functional engineering, but their machines should express a correlation between efficiency of function and harmony of proportion that is deeper than surface beauty. Inventors and engineers keep on improving and perfecting machines and machine products and the day will come when every home will be filled with mass-produced masterpieces which will contribute to a higher level of culture and happiness.

The Cheneys have done a fine job in presenting this striking survey of the movement for industrial design, and engineers should familiarize themselves with the broader aspects of this movement through the excellent study now made available.

Books Received in Library

AMERICAN SAILING CRAFT. By H. I. Chapelle. Kennedy Bros., New York, 1936. Cloth, 8 × 10 in., 239 pp., illus., diagrams, $4. The author discusses the history, design and merits of a great many of the types of sailing craft which were used in American fihseries and commerce during the nineteenth century. Plans and drawings of many are given. The record is as nearly complete as possible, and forms a valuable contribution to our maritime history, which will be welcomed by all interested in boats and boatbuilding.

ATM-ARCHIV FÜR TECHNISCHES MESSEN. Lieferungen 63–66, Sept.-Dec., 1936. R. Oldenbourg, Munich and Berlin. Paper, 8 × 12 in., illus., diagrams, charts, tables, 1.50 rm. This publication is devoted to brief accounts, by specialists, upon new developments in apparatus and methods for technical measurements, and upon the results of new investigations in that field. It also contains manufacturers' descriptions of new instruments and their uses. The articles are classified by a practical system and so arranged that they can be filed in looseleaf binders to form an encyclopedia.

ANALYSES OF BUSINESS CYCLES. By A. B. Adams. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 292 pp., charts, tables, $3. In response to requests for the revision of his "Economics of Business Cycles" to include the histories and analyses of cyclical fluctuations since 1924, Dr. Adams has written this new volume. It discusses the causes of business fluctuations and suggests reforms in business practices which would tend to eliminate extreme ones. Among the topics treated are: Types of business cycles, origin and cumulation of booms, reason for crashes, governmental policies of stabilization, business-cycle theories, forecasting business conditions.

BERICHTE DES DEUTSCHEN AUSSCHUSSES FÜR STAHLBAU, Ausgabe B, Heft 6. Julius Springer, Berlin, 1936. Paper, 8 × 11 in., 22 pp., illus., diagrams, charts, tables, 3.60 rm. The investigations here reported were made at the National Testing Laboratory in Berlin. The first is an investigation of the resistance to buckling of centrally and eccentrically loaded supports with butt joints. The second is an investigation of the influence of shrinkage stresses upon the resistance to buckling of welded compression members under central and eccentric loads.

BETRIEBSERFAHRUNGEN MIT MINERALÖLEN. (Österreichisches Petroleum-Institut, ÖPI-Veröffentlichung 5.) By H. Stäger. Verlag für Fachliteratur Gesellschaft, Vienna, 1937. Paper, 6 × 8 in., 39 pp., illus., diagrams, charts, tables, 2 rm. This pamphlet contains a lecture delivered before the Austrian Petroleum Institute. The changes that occur during use in insulating, lubricating and fuel oils are discussed in the light of practical experience. The effects of air and heat, of contact with metals, and of other influences are described.

BLÄTTER FÜR GESCHICHTE DER TECHNIK, Heft 3, 1936. (Österreichisches Forschungsinstitute für Geschichte der Technik in Wien.) Edited by L. Erhard. J. Springer, Vienna, 1936. Paper, 7 × 10 in., 101 pp., illus., diagrams, charts, tables, 3.60 rm. This interesting contribution to the history of engineering is chiefly devoted to a biography of Viktor Kaplan. The invention and development of the Kaplan turbine are de-

scribed in detail, Kaplan's life is sketched, and a list of his publications given. Other articles include a discussion of the life principle of technology, a description of the Auer von Welsbach memorial exhibition at Vienna, and a bibliography of histories of Austrian industries.

BLUEPRINT READING FOR THE BUILDING AND MACHINE TRADES. By B. F. Hebberger and C. Nicholas. McGraw-Hill Book Co., New York and London, 1937. Cloth, 10 × 12 in., 116 pp., diagrams, $1.80. This course presents a series of fifty-six drawings of increasing difficulty, with detailed descriptions and questions for the student. It is intended for mechanics and students in vocational schools and is based on extended teaching experience.

BÜCHER DER ANSTRICHTECHNIK (Erstes Buch). Vorträge in Veranstaltungen des Fachausschusses. Edited by Fachausschuss für Anstrichtechnik beim Verein deutscher Ingenieure und Verein deutscher Chemiker durch die Gruppe "Verbreitung anstrichtechnischer Kenntnisse." V.D.I. Verlag and Verlag Chemie, Berlin, 1936. Paper, 8 × 12 in., 99 pp., illus., diagrams, charts, tables, 7.50 rm. This work contains a collection of addresses on various uses of paint and varnish, delivered during the years 1934 and 1935 before the paint sections of the Verein deutscher Ingenieure and the Verein deutscher Chemiker. Raw materials, methods of application and the special questions arising in the painting of hydraulic and marine structures are discussed in the thirty-five papers. The book is the first of a series.

DAVISON'S KNIT GOODS TRADE, 46th Annual, October, 1936, pocket edition. Davison Publishing Co., New York. Cloth, 5 × 8 in., 736 pp., maps, $5. This annual directory provides an exhaustive listing of firms engaged in the trade as manufacturers, spinners, dyers, jobbers, agents, wholesalers, etc. Over 2300 mills are included. The book contains all the information usually wanted by buyers and sellers.

DEUTSCHES MUSEUM, Abhandlungen und Berichte, Jg. 7, HEFT 6. Die STADTGASINDUSTRIE, ein Abriss ihrer geschichtlichen Entwicklung by A. Thau. Berlin, V.D.I. Verlag, 1935. Paper, 6 × 8 in., 164 pp., illus., diagram, 0.90 rm. A brief, popular account of the development of illuminating gas manufacture, from the beginnings to the present day.

ELECTRIC ARC WELDING PRACTICE. By H. I. Lewenz. Crosby Lockwood & Son, London, 1936. Cloth, 6 × 9 in., 126 pp., illus., diagrams, charts, tables, 8s 6d. The principles and practice of arc welding are clearly described in this small volume, which is intended to assist those who have actually to carry out the work. Chapters are devoted to materials, electrodes, types of joints, weld testing, shop arrangement and equipment, the applications of welding, and the welding of cast iron.

GEAR DESIGN SIMPLIFIED. By F. D. Jones. Industrial Press, New York, 1936. Cloth, 9 × 11 in., 139 pp., diagrams, tables, $3. The book consists of a series of charts which illustrate, by simple diagrams and examples, the solution of all the usual problems of gear design. The types of gears included are spur, straight-tooth and spiral bevel, helical, herringbone, and worm gears. Information is also provided upon the determination of gearing ratios and speeds and on the power-transmitting capacity of gears. The book is a practical compilation of data for designers and shop men.

DIE GETRIEBEBERECHNUNG UNTER BESONDERER BERÜCKSICHTIGUNG DER DREHZAHLNORMUNG. By A. Wallichs and H. Schöpke. V.D.I. Verlag, Berlin, 1936. Paper, 6 × 8 in., 47 pp., diagrams, charts, 5 rm. Intended as an aid for the designer of gearing, this brochure contains graphs and tables by which the number of teeth for any form of gearing can be determined without calculating the ratio.

Great Britain. Department of Scientific and Industrial Research. Report of the FOOD INVESTIGATION BOARD for the year 1935. His Majesty's Stationery Office, London, 1936. Paper, 6 × 10 in., 232 pp., illus., diagrams, charts, tables. (Obtainable from British Library of Information, N. Y., $1.10.) The report summarizes the work done upon the handling and storage of foods, including work upon various engineering problems of refrigeration.

HISTORY OF THE DISCOVERY OF PHOTOGRAPHY. By G. Potoniée, translated by E. Epstean. Tennant and Ward, New York, 1936. Cloth, 6 × 10 in., 272 pp., $8. This history affords a comprehensive account of the origin of photography and of its development to the end of the daguerrean period, about 1851. The history of the camera obscura is traced from the year 1267 to the first photographic camera in unusual detail, and the work of Niepce, Daguerre and other early workers is discussed and evaluated. The beginnings of photomechanical processes, color photography, stereoscopy and motion pictures are also described.

(KEMPE'S) ENGINEER'S YEAR-BOOK of Formulae, Rules, Tables, Data, and Memoranda for 1937, 43rd Annual Issue, reviewed by L. St. L. Pendred. Morgan Brothers, London, 1937. Leather, 5 × 7 in., 2676 pp., illus., diagrams, charts, tables, 31s 6d. This well-known reference book has reached its forty-third annual issue. It deals with every phase of engineering and, by reason of its frequent issue, affords a convenient survey of modern practice. In this edition the sections upon machine tools, airplane engines, and paints and varnishes have been thoroughly reworked.

KENT'S MECHANICAL ENGINEERS' HANDBOOK. Wiley Engineering Handbook Series, vol. 2, Power. Eleventh edition. Founded by the late W. Kent, rewritten by R. T. Kent. John Wiley & Sons, New York and London, 1936. Leather, 6 × 9 in., 1254 pp., diagrams, charts, tables, $5. The new edition of this famous handbook has been extensively revised, reset, and rearranged. In the new form it has a larger page and type, and appears in two volumes, dealing respectively with power and with design and shop practice. The power volume only has appeared. Sections are devoted to the fundamental principles and practical applications of air, water, heat, combustion, fuels and steam, steam boilers and engines, steam turbines, condensing and cooling, refrigeration, heating and ventilation, internal-combustion engines, gas producers, transportation and electric power. The work has been brought thoroughly up to date and will be an indispensable reference book.

KRAFTFAHRTECHNISCHE FORSCHUNGSARBEITEN 3 AND 4. V.D.I. Verlag, Berlin, 1936. Paper, 8 × 12 in., illus. diagrams, charts, tables, Heft 3, 26 pp.; Heft 4, 33 pp., 3.50 rm each. The contents of No. 3 of this series of automobile studies include: An investigation of the combustion of German heavy oils in a test bomb; the problem of automobile noises; the further development of the glow-lamp meter; measurement of exhaust gases. No. 4 contains: An investigation of the rigidity of self-supporting automobile bodies; tests of an air-cooled six-cylinder engine with a completely closed air circulation; the development of a fully automatic fuel meter; Tests of the lighting of rear license plates.

LOCKWOOD'S DIRECTORY OF THE PAPER AND ALLIED TRADES. Sixty-second edition. Lockwood Trade Journal Co., New York, 1937. Cloth, 6 × 9 in., 1177 pp., illus., $7.50. This directory of the paper trade provides complete information upon the paper mills of North America, classified geographically and by products, and gives lists of manufacturers of paper products and of merchants, trade associations, manufacturers of machinery, and others associated with the trade. The work has long been the standard guide in its field.

MACHINE DESIGNERS' GUIDE. By K. W. Najder. Second edition. Edwards Brothers, Ann Arbor, Mich., 1936. Cloth, 6 × 9 in., 259 pp., diagrams, charts, tables, $2.75. This volume, designed to assist the practical engineer and designer in the quick solution of everyday problems without the use of higher mathematics, contains formulas and tables relating to mechanics, graphics, and the strength of materials. The use of these data is illustrated by a collection of sixty-six worked examples.

MACHINERY AND EQUIPMENT OF THE CANE SUGAR FACTORY. By L. A. Tromp. Norman Rodger, London, 1936. Cloth, 7 × 10 in., 644 pp., illus., diagrams, charts, tables, $8. A comprehensive treatise on the design, construction, and equipment of cane-sugar factories, by an experienced engineer. Every step in manufacture, from the transportation of the cane to the storage of the finished products, is discussed in detail and illustrated by over 600 drawings made by the author. A large number of photographs of machines are also presented. Both the theoretical and practical aspects of the subject are considered.

MACRAE'S BLUE BOOK with which has been incorporated Hendrick's Commercial Register. Forty-fourth edition. 1936–1937. MacRae's Blue Book Co., Chicago. Cloth, 8 × 11 in., 3372 pp., $15. The forty-fourth issue of this annual directory follows the established lines but has been thoroughly revised. It includes lists of manufacturers of all industrial products, of trade names, trade facilities, etc., and provides ready knowledge of the makers of any desired product.

MASCHINENELEMENTE-TAGUNG AACHEN, Bericht über die Tagung des Fachausschusses für Maschinenelemente in Aachen 1935. V.D.I. Verlag, Berlin, 1936. Paper, 8 × 12 in., 64 pp., illus., diagrams, charts, tables, 9 rm. Reports the proceedings of a meeting of the machine parts division of the Verein deutscher Ingenieure, at Aachen in 1935. The papers consider the stresses in machine parts, methods of determining stress distribution by models, reports on recent investigations of lubrication and friction and other timely subjects.

MATERIALPRÜFUNG MIT RÖNTGENSTRAHLEN UNTER BESONDERER BERÜCKSICHTIGUNG DER RÖNTGENMETALLKUNDE. By R. Glocker. Second edition. Julius Springer, Berlin, 1936. Cloth, 6 × 9 in., 386 pp., illus., diagrams, charts, tables, 33 rm. A comprehensive, practical text upon the application of X-rays to the study of metals. The production of X-rays, their properties, and the applications to the inspection of structures and machine parts, to spectrum analysis, and to the investigation of the structure of metals are discussed. Theoretical matters are treated briefly, the emphasis being upon practical methods of procedure. This edition has been entirely rewritten.

MECHANICAL POWER TRANSMISSION HANDBOOK. By W. Staniar. McGraw-Hill Book Co., New York and London, 1936. Leather, 6 × 9 in., 488 pp., illus., diagrams, charts, tables, $5. This handbook aims to be a compact book of reference for plant superintendents and engineers, designers, draftsmen, and students concerned with the proper selection and application of equipment for transmitting power mechanically. Gearing, belting, shafting, bearings, chain drives, etc., are discussed in the light of current good practice and much that is of practical information is supplied.

MECHANICAL TESTING OF METALS AND ALLOYS. By P. F. Foster. Pitman Publishing Corporation, London and New York, 1936. Cloth, 6 × 9 in., 267 pp., illus., diagrams, charts, tables, $3.75. This is a convenient manual for those concerned with mechanical testing and for students of the strength of materials. The work is confined to the types of testing equipment found in modern test rooms and laboratories, and to the range of tests usually made. The equipment and its use are described in clear detail, with the theory that underlies present developments in the field of testing. A brief bibliography is included.

MECHANICS OF TURBULENT FLOW. By B. A. Bakhmeteff. Princeton University Press, Princeton, N. J., 1936. Cloth, 6 × 9 in., 101 pp., illus., diagrams, charts, tables, $3.50. This work contains lectures delivered at Princeton University in 1935. They deal with recent advances in our knowledge of turbulent flow and aim to present a systematic, simple account of these developments which can be easily mastered and turned to account by the practical engineer. The work of Prandtl and von Kármán and their followers is made accessible to English-speaking engineers, with avoidance of higher mathematics.

MERKBÜCHER DER ANSTRICHTECHNIK, Heft 2. EIGENSCHAFTEN DER FARBFÜLLSTOFFE in technischer und wirtschaftlicher Beziehung, by H. Wagner. V.D.I. Verlag, Berlin, 1936. Paper, 4 × 6 in., 22 pp., illus., diagrams, tables, 0.65 rm. A very brief practical description of the properties of inert fillers for paints.

METHODIK UND ANWENDUNGSMÖGLICHKEIT DER ZEITSTUDIE IN DER TEXTILINDUSTRIE. By P. Bergfeld. V.D.I. Verlag, Berlin, 1936. Paper, 6 × 8 in., 84 pp., illus., diagrams, charts, tables, 4.50 rm. Presents the results of an extensive series of time studies carried out in some fifty German textile mills. Especially, the author has concerned himself with a development of sound methods of studying textile processes and of utilizing the results of time studies.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN, Bd. 4, Heft 10. Berlin, V.D.I. Verlag, December, 1936. Paper, 8 × 12 in., pp. 239–266, illus., diagrams, charts, tables, 3.15 rm. This number includes a description of a method for determining the impact pressure and distribution of the fuel in the Diesel engine during actual operation, an account of the construction of the new boiler plant of the Gutehoffnungshütte at Düsseldorf, and a report on the model experiments at the Dam Testing Plant at the Gustavsburg works of the Maschinenfabrik Augsburg-Nurnberg.

NATIONAL ASSOCIATION OF COST ACCOUNTANTS Year Book, 1936, Proceedings of the 17th International Cost Conference, Cincinnati, Ohio, June 22–25, 1936. Cloth, 6 × 9 in., 329 pp., charts, tables. The yearbook contains the addresses and discussions at this Conference. The topics discussed were: Influence of recent federal legislation; the social security administration; accounting for capital assets and depreciation; present-day problems of inventory valuation and control; and the budgetary method of controlling distribution costs.

OUTLINE OF THE HISTORY OF MATHEMATICS. By R. C. Archibald. Third edition. Mathematical Association of America, Inc., Oberlin, Ohio. Paper, 6 × 9 in., 62 pp., $0.50. This interesting sketch of the development of mathematics is based upon two lectures delivered in 1931 at a summer school for engineering teachers organized by the Society for the Promotion of Engineering Education. The history covers the important developments before the nineteenth century, with some more recent developments of topics which are usually discussed in undergraduate colleges. A good bibliography is appended.

PACKAGING, PACKING, AND SHIPPING. Edited by J. O. Rice, published for the American Management Association by Elliot Publishing Co., New York, 1936. Cloth, 8 × 12 in., 235 pp., illus., $7.50. An interesting collection of papers upon the sales value of attractive packaging of merchandise, the design of packages, packaging materials, package engineering, and packing for shipping, in which various authorities present the results of their experience. The papers were presented at conferences sponsored by the American Management Association, and the book is illustrated with representations of packages to which awards were made at these conferences.

PRACTICAL PHOTO-MICROGRAPHY. Third edition. By J. E. Barnard and F. V. Welch. Longmans, Green & Co., New York, 1936. Cloth, 6 × 9 in., 352 pp., illus., diagrams, charts, tables, $8.25. This is the third edition of an excellent text, which has long been popular. The microscope and its optical equipment, sources of illumination, the camera, the manipulation of the microscope, and the photographic processes are considered in detail. Chapters are devoted to special processes and to the use of ultraviolet light. The book has been partly rewritten and additions made at various points.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN, AND PRACTICE. Fourth edition. Lincoln Electric Co., Cleveland, Ohio, 1936. Leather, 6 × 9 in., 819 pp., illus., diagrams, charts, tables, $1.50. The equipment and technique of arc welding, the design of arc-welded machinery and structures, and the applications of arc welding in manufacturing, construction, and repairs are discussed in a practical manner in this well-known work. The new edition contains much new matter covering recent developments and applications.

REGELN FÜR MESSVERFAHREN BEI ABNAHMEVERSUCHEN. Teil I: Regeln für Temperaturmessungen (V.D.I. Temperaturmessregeln). V.D.I. Verlag, Berlin, 1936. Paper, 8 × 12 in., 10 pp., diagrams, charts, tables, 2 rm. This brochure supplements the rules for acceptance tests of engines and machinery adopted by the Verein deutscher Ingenieure by providing a fuller discussion of the details of temperature measurements. The calibration of the various commercial thermometers for different purposes is explained, and rules for their proper use are given. Methods are given for retesting thermometers. A bibliography is included.

REGELN FÜR WASSERMENGEN-MESSUNGEN BEI ABNAHME VON WASSERKRAFTMASCHINEN. (V.D.I. Wassermengenmessregeln.) Edited by Verein deutscher Ingenieure and Reichsverband der deutschen Wasserwirtschaft V.D.I. Verlag, Berlin, 1936. Paper, 8 × 12 in., 12 pp., illus., diagrams, charts, tables, 2 rm. This pamphlet gives the official rules for measuring the water in acceptance tests of hydraulic motors. Exact directions for weir and current-meter measurements are given, together with brief directions for other methods which may be used in special cases. An extensive bibliography is included.

THE RENAISSANCE OF PHYSICS. By K. K. Darrow. The Macmillan Co., New York, 1936. Cloth, 6 × 9 in., 306 pp., diagrams, illus., charts, tables, $3. This book is intended primarily for the intelligent layman who wishes to understand modern developments in physics. In readable, nonmathematical language, Dr. Darrow discusses the constitution of matter, transmutation, and other basic questions. The book is based upon a course of lectures which were given at Lowell Institute.

ROTARY DRILLING HANDBOOK. By J. E. Brantly. Russell Palmer, London and New York, 1936. Leather, 5 × 7 in., 304 pp., illus., diagrams, charts, tables, $3.50. A practical handbook describing the equipment and methods used in drilling oil wells, by an experienced engineer. A large collection of useful tables and formulas is included.

Science Museum, Board of Education. SAILING SHIPS, Their History and Development. Pt. 2. Catalogue of Exhibits, with Descriptive Notes. Second edition. His Majesty's Stationery Office, London, 1936. Paper, 6 × 10 in., 122 pp., illus., tables, 2s 6d. (Obtainable from British Library of Information, New York, $0.80.) This volume is a catalog of the collection of ship models exhibited in the Science Museum, London, and so supplements the historical account of the development of these vessels previously published by the Museum. Two hundred and seventy models are described, thirty-five of which are illustrated by excellent photographs.

SCIENCE MUSEUM. Board of Education. Handbook of the Collections Illustrating

Time Measurement. Part 1, Historical Review, by F. A. B. Ward. His Majesty's Stationery Office, London, 936. Paper, 6 × 10 in., 66 pp., illus., charts, 1s. 6d. Obtainable from British Library of Information, New York, $0.50. This brochure is an interesting, brief history of the development of timekeepers, from the earliest times to the present day. The first two chapters discuss the scientific aspects of time measurement; the later chapters give an account of the historical development of sundials and water-clocks, mechanical clocks, watches, chronometers, Japanese clocks, electric clocks, chronographs, time recorders, time switches and alarms, and striking mechanisms. The history is well illustrated with unusually excellent photographs.

Spanlose Formung der Metalle. Eigenspannungen in Metallen. (Handbuch der Metallphysik, Bd. 3, Lieferung 1.) By G. Sachs. Leipzig, Akademische Verlagsgesellschaft, 1937. Paper, 7 × 10 in., 228 pp., illus., diagrams, charts, tables, 22 rm. This volume contains two valuable monographs by Professor G. Sachs. The first of these is a comprehensive review of existing knowledge upon the working of metal for forging, stamping, rolling, and drawing. The theory of the deformation of metals is discussed in general and with reference to the individual processes, and information on flow phenomena, power consumption, and other matters is given. The second monograph deals with internal stresses in metals, their effects, measurement, causes, and removal. Both of these papers have long bibliographies. The work forms the first section of the third volume of the "Handbuch der Metallphysik."

Statistical Mechanics. By R. H. Fowler. Second edition. The Macmillan Co., New York; University Press, Cambridge, England, 1936. Cloth, 7 × 11 in., 864 pp., diagrams, charts, tables, $14. This monograph presents a systematic exposition of the equilibrium theory of statistical mechanics, envisaging both classical and quantized systems. The new edition has been thoroughly revised and modernized, and some new subjects added, such as ferromagnetics and semiconductors. It retains its position as the leading source of information upon the theory of the properties of matter in equilibrium.

Statistical Year-Book of the World Power Conference. No. 1. 1933 and 1934. Edited, with an introduction and explanatory text by F. Brown. World Power Conference, Central Office, London; American Committee, Interior Building, Washington, D. C., 1936. Paper, 9 × 11 in., 111 pp., tables, $5. This yearbook contains statistics of the resources, stocks, imports, exports, and consumption of power and power sources during 1933 and 1934 for all countries for which t was possible to obtain information. The power sources included are coals, brown coal and lignite, peat, wood, petroleum, benzols, natural gas, water power, and electricity. In most cases the statistics were specially supplied by the National Committees of the World Power Conference and by government agencies, and conform to standard definitions which are given in the text. The book provides a collection of unusually comprehensive and accurate data, which have the great value of being closely defined and comparable.

A Survey of the Present Organization of Standardization; National and International, published by the Central Office of the World Power Conference, London, W.C. 2, 36 Kingsway, 1936. Paper, 7 × 11 in., 55 pp., tables, 3s 6d. Gift of American National Committee, Interior Building, Washington, D. C. This brochure presents the facts regarding the national organization of standardization in thirty-three countries, and also of two international bodies. The organizations in each country are described and their functions explained. The report was prepared by the International Executive Council of the World Power Conference.

Steam-Electric Power Stations. By C. F. John. International Textbook Co., Scranton, Pa., 1936. Leather, 5 × 8 in., illus., diagrams, charts, tables, $1.50. An elementary descriptive text on power-plant equipment and operation, designed for operating men.

Symposium on High-Strength Constructional Metals. Pittsburgh Regional Meeting, A.S.T.M. March 4, 1936. American Society for Testing Materials, Phila., Pa., 1936. Paper and cloth, 6 × 9 in., 126 pp., illus., diagrams, charts, tables; paper, $1.25; cloth, $1.50. This brochure contains five papers presented at a recent meeting of the Society. The papers discuss alloys of aluminum, magnesium, copper and of nickel, carbon and low-alloy steels, and corrosion-resisting steels. The chemical and physical properties of these materials, and their manufacturing and fabricating properties are presented.

Technology of Plastics. By H. W. Rowell. Plastics Press, Ltd., London, 1936. Cloth, 6 × 9 in., 206 pp., illus., diagrams, charts, tables, $4. The aim of this book is to provide in simple form the essential technical particulars of the plastics industry. It covers broadly the composition, properties, and manufacture of the moldable and molded plastics on the market and describes the plant, principles, and technique used in molding them.

Thermodynamics. By J. E. Emswiler. Fourth edition. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 351 pp., diagrams, charts, tables, $3. A text on the fundamentals of the subject which presents them with especial regard to the viewpoint of the student. In the presentation steam is considered first and then in succession vapor refrigeration, permanent gases, mixtures, and air-heat engines. The laws of thermodynamics and the kinetic theory of heat are treated last. This new edition contains new material on water-vapor refrigeration and on the steam-air mixture. The material which deals with the energy laws of thermodynamics has been changed and new problems have been added.

Thermodynamic Properties of Steam, Including Data for the Liquid and Solid Phases. By J. H. Keenan and F. G. Keyes. John Wiley & Sons, New York, 1936. Cloth, 7 × 10 in., 89 pp., charts, tables, $2.75. Since Keenan's "Steam tables and Mollier diagram" appeared in 1930, research in the properties of steam has been actively in progress. Large gaps in the experimental work have been filled in and the regions investigated have been extended. The present volume therefore is much more complete and accurate than its predecessor. The new tables extend from —40 to 1500 F and to 5500 lb per sq in. The Mollier diagram has been extended, and there are included tables of viscosities, heat conductivity, the properties of ice and compressed liquid water, isotropic-expansion coefficients, specific heats, and conversions.

Thermodynamics. By S. E. Winston. American Technical Society, Chicago, 1937. Cloth, 6 × 9 in., 178 pp., illus., diagrams, charts, tables, $1.50. This text aims to present, in the simplest possible manner, those more general principles of thermodynamics that are of importance to those engaged in heat-power engineering, refrigeration, and air conditioning. Calculus is not used. Many problems are included.

Tungsten, a Treatise on its Metallurgy, Properties, and Applications. By C. J. Smithells. Second edition. D. Van Nostrand Co., New York, 1936. Cloth, 6 × 9 in., 272 pp., illus., diagrams, charts, tables, $8. This treatise provides a comprehensive review of the metallurgy and properties of tungsten and its alloys, and of their industrial applications. The new edition is thoroughly revised and greatly enlarged.

Value Theory and Business Cycles. By H. L. McCracken. Second edition. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 259 pp., charts, $4. Primarily designed to bring out the vital and fundamental relationship between value theory and business cycles, Dr. McCracken has extended his text in this edition by a discussion of modern theories of business cycles. In addition, he gives an analysis and appraisal of rigid vs. flexible prices as alternative techniques for achieving business stability at a high level both of production and of consumption.

Ventilateurs Soufflantes et Compresseurs Centrifuges. By C. Monteil. Dunod, Paris, 1937. Paper, 7 × 10 in., 140 pp., illus., diagrams, charts, tables, 28 fr. This text presents the course in centrifugal fans and compressors given at the École Centrale des Arts et Manufactures. The theory and design of these machines are considered from the viewpoints of builder and user.

Water Treatment and Purification. By W. J. Ryan. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 8 in., 242 pp., illus., diagrams, charts, tables, maps, $2.50. The aim of this book is to describe, in a single volume, the several processes of purification and treatment that are applied to water. The construction and operation of the different types of filtering, softening, and treating apparatus are described concisely, yet clearly, and lists of articles affording further data are given. The book affords the reader a convenient summary of practice.

Wöhler-Institut, Braunschweig. Mitteilungen, Heft 28. Friedr. Vieweg & Son, Braunschweig, 1936. Paper, 6 × 8 in., 91 pp., illus., diagrams, charts, tables, 5 rm. This brochure contains two reports of investigations at the Wöhler Institute. The first is a study, by H. Sonnemann, of the fatigue resistance and damping capacity of commercial steels and Armco iron, and of the influence of cold riveting upon these properties. The second is a brief report, by Professor Föppl, upon the reduction of the vibration of internal-combustion engines by rubber supports.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Tours and Sight-Seeing Features of A.S.M.E. Semi-Annual Meeting, Detroit, May 17–21

Technical Program to Survey Mass Production

AN IMPORTANT feature of the 1937 Semi-Annual Meeting, Detroit, Mich., May 17 to 21, will be the sight-seeing and technical inspection tours arranged by the local committee for visiting engineers and the ladies in attendance. Detroit offers more than usual opportunities for trips of both types, for not only is it the home of a variety of engineering industries, including the automobile, but it has an interesting history, a strategic commercial location, and attractive environs.

Technical Program to Survey Mass Production

As announced last month the general program of the meeting at Detroit will be based upon a series of six sessions at which eminent authorities from engineering and industrial fields in the Detroit area will develop a broad survey of modern techniques employed by mass-production industries typified by the building of automobiles. In addition simultaneous sessions of the professional divisions of the Society will provide opportunity for the presentation and discussion of papers along the lines of their special interests. But it is the intention of those arranging the program to avoid as much as possible the annoying conflicts of schedule that force members to choose between two events, both of which they wish to attend. The meeting, which will be preceded by a meeting of the Council and will include a business meeting of the Society and a banquet, will be held at the Statler Hotel.

The details of the complete program of the Detroit meeting are being whipped into shape by the various committees concerned and time and place schedules will be announced later. Last month an attempt was made to give a general idea of the subject matter to be discussed in the technical papers. This month the Detroit committee has provided a list of some of the important plants to which inspection trips are now being planned, and a brief account of what women visitors may expect to find provided for their entertainment.

Major- and Minor-Interest Tours Being Planned

At the present stage of program development it is planned to offer some major-interest tours for members and men guests on Monday afternoon and Friday. Inasmuch as no technical sessions are scheduled for Monday afternoon, there will be no counter attractions to draw members who arrive in time from these tours. Minor-interest tours will be conducted on Tuesday, Wednesday, and Thursday afternoons.

In order to provide a general idea of what Detroit has to offer the visiting engineers in the way of sight-seeing and plant inspection tours, the local committee has made up the following list of places to which it expects to conduct members of the Society.

Some of the Places to Be Visited

The City of Detroit itself, with its commercial, industrial, and residential districts, supports a population fourth in size of the cities of the United States, having grown from a trading fort constructed in 1701 by the Frenchman, Cadillac. Its location on the Detroit River has made it an important commercial center since its start, and it has much to offer the visitor in the charm and interest of its parks and institutions.

Courtesy Detroit Convention and Tourist Bureau

THE ORIGINAL EDISON LABORATORY FROM MENLO PARK, GREENFIELD VILLAGE

The Edison Institute and Museum, located at Dearborn, constitute one of Henry Ford's educational projects, named in memory of his friend, Thomas A. Edison.

Greenfield Village, adjoining the Institute, comprises buildings representative of American life, some of historical importance, most of which were moved bodily from their original locations. The original Edison laboratory, formerly at Menlo Park, is one of the buildings thus preserved by Mr. Ford at Greenfield Village. The Institute, the Museum, and the Village are sought out by sight-seers from all over the world.

The Ford Rouge plant, covering almost eleven hundred acres, offers an opportunity to witness automobile production from the ore pile to the finished car, and is an object of interest and admiration to all who visit it. Features of the proposed trip to the Ford Motor Company will be the central rotunda which was moved from the Century of Progress exposition in 1935, the fabrication and assembly plants where Ford cars are made, and the 1250-lb steam power plant.

The Great Lakes Steel Corporation's plant, also on the list of visits, is said to be one of the most modern steel plants in existence. The mills produce hot- and cold-rolled strip steel up to 90 in. wide, merchant bars, automobile-bumper sections, spring steel, forging bars, miscellaneous bar-mill sections, billets, automobile sheets, and other steel products.

Conners Creek, of The Detroit Edison Company, is the scene of the rehabilitation of an existing 225-lb, 600-F steam plant into a 600-lb, 825-F power plant. The present new installation includes three 30,000-kw and two 60,000-kw turbine generators and eight new steam-generating units. Power engineers will not wish to miss the opportunity of visiting this famous power plant.

The Springwells pumping station, which will be visited after a paper has been read in which certain features of design and operation are to be described, is the recently constructed power and pumping station of the Detroit Department of Water Supply.

Examples of production methods in the automobile industry in and around Detroit will be witnessed by those who take part in the inspection tours arranged at the Plymouth assembly line, the Chevrolet forge and axle plant, the Packard forge and assembly line, and the Dodge Bros. body plant. In connection with papers on rubber, arrangements are being made for a visit to the United States Rubber Company.

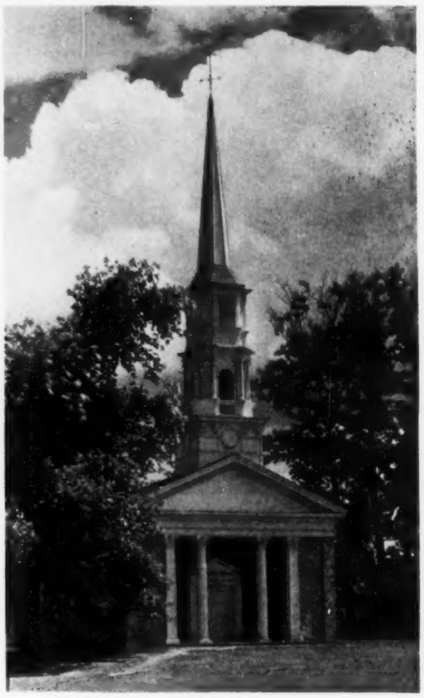
Cleveland Engineering Society to Join in Trips

Announcement has been made of the fact that the Engineering Society of Detroit is to be the host to the Cleveland Engineering Society on Friday, May 21. Inasmuch as the members of the Cleveland Engineering Society have requested that they participate in the inspection tours of the A.S.M.E. Semi-Annual Meeting, and wish to see Conners Creek and the Ford Rouge plants, Conners Creek has been scheduled as a major tour on Friday morning and the Ford Rouge plant on Friday afternoon. Other tours through these plants will be scheduled earlier in the week.

Women Will Have an Interesting Program

An active and alert committee of Detroit women is engaged in making arrangements for the entertainment of women guests at the Detroit Semi-Annual Meeting.

The committee is under the chairmanship of Mrs. P. W. Thompson. With Mrs. Thompson are serving Mrs. James W. Armour, Mrs. Sabin Crocker, Mrs. C. J. Freund, Mrs. A. N. Goddard, Mrs. Louis Knocke, Mrs. A. M. Selvey, Mrs. J. H. Walker, Mrs. A. E. White, and Miss R. Kluzak. F. D. Campbell and A. M. Selvey are acting as secretary and alternate secretary, respectively, of the committee.



CHAPEL OF MARTHA-MARY
(Typical Colonial Church in Greenfield Village.)

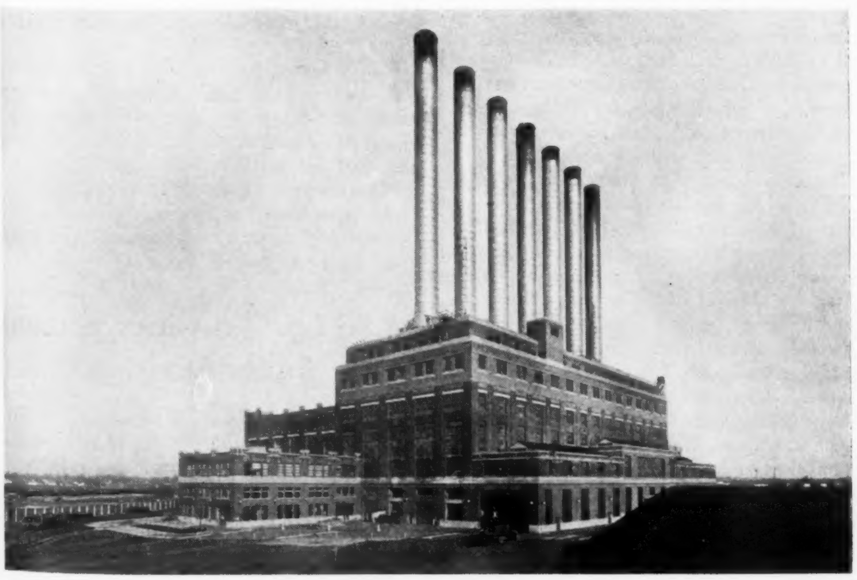
Tentative plans call for sight-seeing and inspection trips for Monday afternoon and evening, for Tuesday and Wednesday morning and afternoon, and for Thursday morning. Arrangements are being made for a luncheon, en route to the Cranbrook Foundation. On Thursday noon luncheon will be served at the Detroit Yacht Club, to be followed by a bridge party at the club.

The women are invited to attend the session on Wednesday morning, at which William S. Knudsen, of General Motors, is scheduled to speak. Thursday evening they will join with members of the Society and their guests at the banquet to be held at the Hotel Statler.

Some of the Sight-Seeing Trips

The women's program for the 1937 A.S.M.E. Semi-Annual Meeting at Detroit, May 17 to 21, includes some novel entertainment features, among which are visits to some of the nationally known points of interest around Detroit, such as The Cranbrook Foundation, The Edison Institute and Greenfield Village, and Belle Isle. Free transportation is provided for all sight-seeing trips.

Few industries have ever caught women's imagination as has the manufacture of automobiles. The women's tour through the Ford Rouge plant has been laid out to display spectacular features such as the assembly line and mass-production machine shops. These portions of the plant are readily accessible via specially constructed aisles and walkways from which operations can be viewed in cleanliness and comfort. Transportation to the various buildings and conduct through the shops is carefully arranged to minimize fatigue.



CONNERS CREEK PLANT

DETROIT COMMITTEE FOR SEMI-ANNUAL SPRING MEETING OF A.S.M.E.

(Front row, left to right: Ernest Hartford, A.S.M.E. Headquarters; H. T. Woolson, Chairman, Papers Committee; J. W. Parker, General Chairman; Mrs. P. W. Thompson, Chairman, Ladies Committee; J. W. Armour, Chairman, Reception and Registration Committee; L. T. Knocke, Chairman, Detroit Section. Back row, left to right: C. M. Drake, Member, Hotel Committee; Floyd B. Price, Vice-Chairman, Inspection and Tours Committee; L. J. Schrenk, Chairman, Publicity Committee; B. W. Beyer, Chairman, Hotel Committee; A. M. Selvey, Secretary, Recording Meetings Committee; Sabin Crocker, Secretary, General Committee; Frank J. Oliver, Chairman, Recording Meetings Committee; F. D. Campbell, Secretary, Ladies Committee. Absent: E. W. Nicklin, Chairman, Finance Committee; Dean C. J. Freund, Secretary-Treasurer, Detroit Section; Jervis B. Webb, Chairman, Inspection Tours Committee.)

Parties are received at the Ford Rotunda, removed from the Century of Progress in Chicago and reerected permanently in Dearborn, where they view the unique and world-famous photomurals and many beautifully arranged dioramas. Carefully trained guides appear, comfortable buses draw up, the parties take seats and are on their way for an intriguing afternoon around the immense Ford plant. Ingenious automatic machines, acting almost humanly, are seen. Snake-like conveyors, winding overhead, carry parts from these machines toward the assembly lines. A principal assembly line is viewed from a protected walkway. The complete creation of a car is seen, from the chassis frame to the finished automobile.

From this bird's-eye view of the auto industry, the ladies turn to the Cranbrook Foundation, gems of architecture set in a beautifully landscaped campus. This little community of art and learning is situated in Bloomfield Hills, a few miles from Detroit. To the Academy of Art has come the outstanding talent of Europe. Here may be viewed the outstanding work of Mr. and Mrs. Eliel Saarinen, the distinguished Finnish architects, and Mr. Carl Milles, the noted sculptor. The Cranbrook School for Boys has all the spirit and dignity of an English public school. The Kingswood School for Girls, set in a picturesque environment, has high scholastic standards and meets all modern educational requirements. No visit is complete without a pause in Christ Church to hear the Cranbrook Carillon.

The Edison Institute and Greenfield Village are widely known and need little introduction. The Institute's museum records interesting phases of the history of the English-speaking races by exhibits of choice china, silverware, and furniture, and by displays of agricultural and engineering achievement. Collections are added to constantly and a repeat visit is amply repaid. Greenfield Village, adjacent to the Institute, contains famous historic buildings, such as Thomas A. Edison's Laboratory, and typical examples of the skilled artisan's workshop.

The Grosse Pointe homes of prominent Detroiters with their well-kept lawns and gardens reaching to the edge of Lake St. Clair, upon which may be seen passing the unceasing flow of the Great Lakes' steamer traffic, provide an always intriguing sight for visitors. Other features arranged by the Ladies' Committee include a short stop at the Russell A. Alger Home, now a permanent museum of Italian Renaissance art, and luncheon and afternoon bridge or games at the Detroit Yacht Club on Belle Isle.

Detroit is well served by splendid shops which many women will wish to visit. Visitors may be escorted by local members' wives if they desire, and will quickly find themselves among friends who will gladly give them whatever assistance they can to make their stay more enjoyable.

Metropolitan Special to Detroit

MEMBERS of the Metropolitan Section planning to attend the Detroit Meeting will enjoy their trip still more by taking advantage of the arrangements which have been made with the New York Central Railroad for Special A.S.M.E. Cars. These will be air-conditioned 8-section 5-double-bedroom sleepers leaving Grand Central Terminal, Sunday, May 16, attached to the *Detroiter*, train No. 47, at 6:45 p.m. Eastern Standard Time or 7:45 p.m. daylight-saving time, and due at Detroit 8:15 a.m. the next morning.

The railroad fare in each direction between New York and Detroit on this train is $21.50; lower berth $4.24; upper berth $3.40; bedroom one person $7.65 or two persons $8.50. Reservations may be made through regular ticket agents or through the A.S.M.E. Secretary's office. When making reservations be sure to state that space is desired in the Special A.S.M.E. Car on the *Detroiter*, May 16.

Fall Meeting of the A.S.M.E. at Erie, Pa., Sept. 28–30

IT IS hoped to return to the policy of holding four national Society meetings each year, beginning with a fall meeting at Erie, Pa., September 28–30, with headquarters at the Lawrence Hotel.

Divisions and technical committees are now planning to participate in this meeting. Complete plans for all sessions should be ready not later than July 1.

A.S.M.E. Tri-Cities Section Junior Division

FROM the junior division of the Tri-Cities section of the A.S.M.E. comes a program for 1937 which lists meetings through June of this year. The program is composed of talks, inspection trips, and motion pictures scheduled semi-monthly. Tom S. Lashbrook is chairman of the Junior Division, and A. S. Lundy acts as secretary-treasurer. Edwin K. Bonner is in charge of program.

A.S.M.E. Textile Division to Cooperate in National Rayon Textile Conference

FINAL arrangements are now being made for the National Rayon Textile Conference to be held in Washington, D. C., Friday and Saturday, May 14 and 15, under the cosponsorship of the Textile Division and Washington Section of The American Society of Mechanical Engineers, American Association of Textile Chemists and Colorists, United States Institute of Textile Research, and Committee D-15 of the American Society for Testing Materials. The purpose of the meeting is to bring together members of all technical and scientific organizations connected with the textile industry for the discussion of the various problems of common interest involved in the manufacture and processing of rayon yarns and fabrics.

The tentative program includes the presentation and discussion of papers on the following subjects:

Air conditioning of textile plants making and using synthetic yarns
Mechanics of synthetic-fiber weaving
Throwing of rayon yarn
Dyeing and finishing of rayon and acetate fabrics
Testing of rayon and acetate yarns and fabrics
Manufacture and use of cut rayon staple
Use of corrosion-resistant metals and alloys in rayon equipment

An informal dinner will be held Friday evening at the Wardman Park Hotel, the headquarters of the conference. All textile men interested in the manufacture or processing of rayon yarns and fabrics, whether or not they are members of any of the sponsoring organizations, are cordially invited to attend the conference. Details regarding hotel reservations, etc., may be obtained by writing to M. A. Golrick, Jr., secretary, A.S.M.E. Textile Division, 29 West 39th Street, New York.

A.S.M.E. to Have Local Section at Ithaca

MEMBERS of the Society in the general area of Ithaca, N. Y., including those in Binghamton, Johnson City, and Elmira, will be especially interested in an organization meeting of the Ithaca Section to be held during the week of April 12 at Willard Straight Hall, Cornell University.

Notices will be sent to members of the Section as soon as the arrangements are complete, but other members in the Society who may be contemplating a visit to Ithaca that week, and who may be interested in attending the meeting of the new Section, should get in touch with Prof. Frederick G. Switzer, College of Engineering, Cornell University, the organizing officer, for further details.

A.S.M.E. Calendar

of Coming Meetings

May 7–8, 1937
Graphic Arts Conference, Hotel Commodore, New York, N. Y.

May 14–15, 1937
National Rayon Textile Conference, Wardman Park Hotel, Washington, D. C.

May 17–21, 1937
Semi-Annual Meeting
Detroit, Mich.

June 25–26, 1937
Applied Mechanics and Hydraulics Meeting
Cornell University

August, 1937
Oil and Gas Power Meeting
Pennsylvania State College

October, 1937
Wood Industries Meeting
Louisville, Ky.

Local Sections Meetings
See page 316

T. K. Thomson Describes Engineering Projects to A.S.M.E. Women's Auxiliary

AT A meeting of the Women's Auxiliary of The American Society of Mechanical Engineers, held in the Society rooms on Feb. 11, 1937, T. Kennard Thomson, member, A.S.M.E., consulting engineer of New York, spoke on "The Evolution of Manhattan from an Indian Village to a Great Metropolis." The lecture was illustrated with colored lantern slides.

Among Mr. Thomson's interesting illustrations was a map reconstructed by Edward Van Winkle, member, A.S.M.E., whose wife was the first president of the Women's Auxiliary, from that made in 1639 by Joan Vingboom including what are now parts of New Jersey, Staten Island, and Brooklyn, and published by Major Van Winkle in his historical monograph entitled "Manhattan, 1624–1639." In contrast to this, Mr. Thomson displayed a modern map on which he had included extensions of the island, frequently proposed by him, extending it into the Bay by means of coffer dams between the Battery and Governors Island. The proposed extension would provide a space 6000 ft long and a half mile wide which Mr. Thomson suggests might be used as an airplane landing field.

With an eye to future engineering developments in other parts of the country Mr. Thomson spoke of his proposed "Niagara Falls Junior," at a site 4.5 miles below the present Niagara Falls where, he said, an additional 2,000,000 horsepower might be developed. Another topic to which he directed the attention of his audience was the solution of the Mississippi problem, which, in his opinion, lay in constructing three additional rivers to be followed by the reconstruction of the Mississippi itself.

Courtesy Detroit Convention and Tourist Bureau

REPLICAS OF INDEPENDENCE HALL, CONGRESS HALL, AND THE OLD CITY HALL OF PHILADELPHIA, GREENFIELD VILLAGE

J. F. O'RYAN

R. P. HOBSON

R. R. BELKNAP

A. CLOYD GILL

O'Ryan, Hobson, Belknap, and Gill Address Metropolitan Junior National Defense Group

THE National Defense Study Group of the Junior Group of the Metropolitan Section, The American Society of Mechanical Engineers, is receiving congratulations on its general meeting on National Defense, held in the Engineering Societies Auditorium, Feb. 9, 1937.

Arrangements made by the Group, of which Mathew Alberts is chairman, provided speakers of international reputation and a radio hook-up to carry the addresses to the nation at large. Crosby Field, lieutenant-colonel, Ordnance Reserve, New York Ordnance District, and chairman, Committee on Professional Divisions, The American Society of Mechanical Engineers, presented the speakers, who were entertained at dinner at the Engineers' Club prior to the meeting.

The speakers were Richmond P. Hobson, rear-admiral, U. S. Navy, retired, hero of the bottling of the Spanish fleet in the harbor of Santiago de Cuba during the Spanish American War; John F. O'Ryan, major-general, U. S. Army, retired, Commander of National Guard on the Mexican Border in 1916, commander of the 27th Division, A.E.F., during the World War, Police Commissioner, New York, N. Y., in 1934, and at present vice-president, American Airways, Inc.; Reginald R. Belknap, rear-admiral, U. S. Navy, retired, who organized, equipped, trained, and commanded the U. S. Mine Squadron which laid more than 56,000 mines in the North Sea between June and October, 1918, and served as director of the Strategy Department of the Naval War College from 1921 to 1923; and A. Cloyd Gill, newspaper man of New York, national-defense authority, and radio commentator.

In introducing the speakers Colonel Field called attention to the constantly increased dependence placed on the engineering profession in times of national stress, and the engineering developments that have resulted from military science.

O'Ryan Speaks on the Army's Part

General O'Ryan, whose subject was "National Defense and the Part of the Army," spoke of the misgivings of many citizens both as to the reality of our American isolation and as to our internal security. He reminded his hearers how governments are divided between autocracies and those under the direct rule of the mass, and of the many millions of persons of foreign birth in this country, some of whom undertake to force their views and standards on Americans, with the threat that, under certain circumstances, fighting a foreign foe would entail also a foe within our own borders.

He recommended that the engineering fraternity, with its scientific training, take the lead in supporting practical measures for steadily increasing the strength and efficiency of our military forces. The regular army and its reserves, he said, are a vital reliance for America in dangerous times. He recommended that they be built up to their active strength, and made similar recommendations regarding increasing the strength of the National Guard Reserve. In his opinion, the Corps of Cadets at West Point should be doubled or trebled, and the activities of the R.O.T.C. and the C.M.T.C. should be rapidly expanded.

Perils at Home and Abroad

Admiral Hobson, speaking on "Perils at Home and Abroad," said that as an engineer it was natural for him to feel that the methods of the engineer would prove especially helpful in solving the difficult and complex sociological problems that confront society. Early decisions of the American people, he said, will, in all probability, determine the course of an anticipated world war and world revolution, and probably settle the fate of our free institutions and the cause of peace and freedom throughout the world.

Preparations for a communist revolution in this country have been going on without any serious organized opposition, he asserted; and, in his opinion, the main line of communist attack is to drive a "wedge of hate" into American industry by a succession of strikes. As a corrective he suggested the general adoption of a profit-sharing wage system and "a warehouse system permitting prompt distributions of surplus products to wage earners and stockholders in the form of surplus production warrants, with a ready setup for the exchange of production warrants." He also called for "the support and defense of the Constitution."

In discussing perils abroad Admiral Hobson spoke of the fate of the world should communism conquer in a second world war, or, on the other hand, should fascism crush communism. America's course, he asserted, was to keep out of war, which, in his opinion, could best be accomplished by keeping out of the economics of foreign wars. He was also in favor of strengthening the Neutrality Act. [Admiral Hobson died in New York, March 16.]

Role of Aviation

Major Gill spoke of the role of aviation in national defense, and of preparedness campaigns in aeronautics being carried on in other nations and in the United States, in which, he thought, preparations in this country were inadequate. He ended his address with the question, "So long as a potential enemy regards aviation as a vital arm of our national defense, does it not behoove us to demand and get a military air force capable of repelling an attack, regardless of its source or strength?"

The Navy in National Defense

Speaking on "The Navy's Part in National Defense," Admiral Belknap said that every war in which this country has engaged has shown that, had our defense been ready, the causes that led to war would not have grown beyond control by peaceful negotiation. War making is always many times more costly than war prevention, he asserted.

Calling attention to our foreign trade and trade competition, and the effect of their interruption in warfare, he pointed out that the Navy's task is to prevent invasion of our country and to maintain routes of essential trade—defense on a national scale. Naval preparation, he said, requires considerable time, of which we have already lost much, although our government is now bringing the Navy up to strength. Naval readiness, he concluded, holds would-be aggressors in check by keeping the peace and allowing moral strength among nations to grow.

Hartford A.S.M.E. Juniors Publish "Technical Times"

AN EIGHT-PAGE bulletin called *Technical Times* is being published by the Hartford Junior Section of The American Society of Mechanical Engineers.

The first issue, dated February, 1937, contains a discussion of problems of organization, by Dick Shaw, chairman; editorial comment on aims and policies in which it is stated that the primary purpose of the publication is to disseminate A.S.M.E. and technical news to junior members; problem at the Connecticut State; news notes, questions and answers, and comment on the Engineers' Council for Professional Development.

The editor-in-chief of the *Technical Times* is P. R. de Bruyn and the business manager is S. A. Cooke. S. Grotta and L. Broughton are members of the editorial staff.

Progress and Problems in Agricultural Processing Discussed at Rutgers

A.S.M.E. Process Division, American Society of Agricultural Engineers, and Farm Chemurgic Council Hold One-Day Meeting

MEMBERS of the A.S.M.E. Process Industries Division, the American Society of Agricultural Engineers, and the Farm Chemurgic Council met at Rutgers University on February 26 to discuss progress and problems in the agricultural processing field.

Processing Research for Agriculture

At the morning session at which Prof. R. U. Blasingame of State College, Pa., and president of the A.S.A.E., presided, an interesting paper on "Processing Research for Agriculture" was presented by John P. Ferris, acting director of the agricultural industries division of the T.V.A. Mr. Ferris believed that by increasing the diversification, security, and productiveness of our agricultural regions, engineering helped to bring about a higher standard of living. Manufacturing businesses which use agricultural raw materials increasingly influenced the direction of development of our basic national economies associated with soil. Processing developments were important in helping a raw-material area to diversify its income base. Quick freezing, for instance, brought new income through the addition of labor value to a raw product. Soil-conserving farm practices in the one-crop areas might be furthered by local business. While large industry turned to its research staff, small enterprise should seek access to university laboratories, said Mr. Ferris. Each state engineering college had an opportunity through research to contribute to the best use of its state's industrial resources. An example of this was the University of Tennessee's project in improved processes for cotton-oil extraction.

Processing Flax and Hemp

Outstanding contributions at this meeting were papers on "Processing Flax and Hemp" given by George F. Lowry and James A. Grant, of Lowry & Grant, Inc., New York. These papers were devoted to the purpose of interesting agronomists, chemists, and mechanical engineers in the possibilities of restoring to this country the lost flax and hemp-products industries.

By showing the extravagant wastefulness of present methods, Mr. Lowry explained how wastages may be overcome and how a one hundred per cent gain in manufactured material may be obtained for considerably less money from the same amount of straw. Photographs of old and present types of scutching machines were shown and explained and chemical processes now used in making finished linens were compared with older methods. Samples of fiber, yarn, and fabric were on display.

Mr. Grant's shorter paper dealt with hemp, in which he showed that a fiber practically indistinguishable from flax may be obtained by a process similar to that proposed for the latter.

Luncheon Speakers

At the luncheon in the Elks Building on the campus, there were two speakers, Walter C. Russell, who substituted for Dr. W. H. Martin, director of research of the New Jersey Agricultural Experiment Station, and Dr. Paul L. Hoover. Mr. Russell, who is a biochemist in nutrition at the Station, told of their studies of the preservation of roughages by drying and ensiling methods. Attention, he said, is being given to the growing of flax and Jerusalem artichokes which may be of value in the industrial processes. A number of cooperative industrial-research fellowships have been established at the Experiment Station for the study of problems common to agriculture and industry. Dr. Paul L. Hoover, also of the Experiment Station, devoted his talk to engineering research in this field.

Processing Engineering in Agriculture

Victor Wichum, chairman of the A.S.M.E. Process Industries Division, presided at the afternoon session at which the first paper "Processing Engineering in Agriculture" was delivered by L. F. Livingston, past-president of the American Society of Agricultural Engineers and manager of the agricultural extension section of the explosives department E. I. du Pont de Nemours & Co.

Flood control, soil erosion, and the well-being of our industrial population are all linked with the "agricultural problem" which cannot be solved by a narrow view of remedies for the farmer alone, Mr. Livingston said in his address.

The chemist, the agriculturist, or the engineer alone will not develop the industrial use of agricultural products. Processing engineering as applied to agricultural products destined for the factory is a tremendously important part of a complex operation—an operation which involves a multitude of agencies seemingly foreign to each other.

As an example of the industrial uses of agricultural products, Mr. Livingston cited the consumption of farm products by the du Pont Company during the year 1936. During 1936 it used 35,000,000 pounds of vegetable oils, 7,124,000 pounds of turpentine and rosin, 93,700,000 pounds of wood pulp, 51,293,000 pounds of cotton linters, 20,156,000 pounds of corn products, 40,020,000 gallons of molasses, and 12,500,000 pounds of cotton fabrics. Already more than 62 per cent of this volume comes from American acres. A few years ago this percentage was much smaller.

Recent economic disorders have focused attention upon the agricultural problem. But almost unnoticed and entirely unheralded, a natural growth has been taking place. New industries have been born out of the ever-present need for better things for better living for a greater number of people. These industries are based on the chemical conversion of raw materials taken from the soil, raw materials which are perpetually renewable and which add to the national wealth without impoverishing future generations.

If agriculture is further to grasp the opportunity offered by the industrial market, every effort must be made to make the production cost as low as possible consistent with the maintaining of a reasonable margin of profit for the producer. This problem is being solved by new methods, new machines, new storage facilities. A successful consummation of this program will require the utmost cooperation between all branches of science.

The second paper on the program, "Drying of Agricultural Products—Technical and Economic Aspects," was given by Chas. W. Thomas and A. Weisselberg, members of the Drying Committee of the A.S.M.E. Process Division. Mr. Thomas in discussing the national economic aspect of artificial drying, pointed out that census, average age of population, diet, and method of living pointed to an increase in cultivatable areas, but soil reclaimation and reforestation necessitated a considerable reduction of such areas. More intense cultivation would be essential and this would require artificial drying. Artificial drying was also part of the program for carrying over surpluses and controlling prices. Central drying plants were believed by Mr. Thomas to be the answer.

Mr. Weisselberg discussed the technical aspects of the subject. He took up the matter of costs first, showing the need for improved utility factor before lower operating expenses are attempted. To lower operating expenses, lower moistures were essential for artificial drying. Mechanical separation of juices and subsequent drying of the mixture of pulp and juices thickened in evaporators was one of the recommendations for lower heat consumption. The various factors limiting the performance of the driers were gone into and the need shown for more data on final moisture and rates of regain. A discussion of the kind of driers suitable for agricultural products, both for the portable unit and for the central plant, concluded the paper.

Section M Officers Elected at A.A.A.S. Meeting

AT THE Atlantic City meeting of the American Association for the Advancement of Science, J. W. Barker, member, A.S.M.E., dean of engineer, Columbia University, was elected vice-president of Section M, Engineering; and F. M. Feiker, member, A.S.M.E., executive secretary, the American Engineering Council, was elected secretary. F. L. Bishop, of the University of Pittsburgh, secretary, S.P.E.E., was elected a member of the sectional committee.

Actions of A.S.M.E. Executive Committee

A MEETING of the Executive Committee of The American Society of Mechanical Engineers was held in the Society rooms on Feb. 18, 1937. The following were present: James H. Herron, president of the Society; Harry R. Westcott, William A. Shoudy, James W. Parker, and Kenneth H. Condit, of the committee; and the following advisory members representing standing committees: K. M. Irwin, Finance; Crosby Field, Professional Divisions; and J. N. Landis, Local Sections. W. D. Ennis and C. E. Davies, treasurer and secretary of the Society, respectively, were also present.

Among actions of general interest the following are noted:

Junior Dues

The Secretary reported correspondence with Sabin Crocker, of the Detroit Section, regarding the rate of dues for junior members who will be subject to the provisions of the constitution now under consideration in which he pointed out that the new provisions for dues rates cannot be made retroactive, and will become effective only after the ballot to the membership has been canvassed. This means that the provisions will be effective beginning with the dues billed Oct. 1, 1937. Junior members under financial stress are expected to make individual requests for relief for consideration by the Board of Review.

Council Assignments to Professional Divisions

In line with suggestions made at the Annual Meeting that members of the Council be assigned to the several professional divisions, and upon the recommendation of the Committee on Professional Divisions, the following assignments were made:

To the Iron and Steel and Management Divisions, W. L. Batt.

To the Petroleum Division, E. W. Burbank.

To the Applied Mechanics and Hydraulic Divisions, S. W. Dudley.

To the Aeronautic Division, W. Lyle Dudley.

To the Fuels, Power, and Railroad Divisions, J. W. Haney.

To the Textile and Wood Industries Division, W. C. Lindemann.

To the Materials Handling and Process Industries Divisions, R. J. S. Pigott.

To the Oil and Gas Power Division, R. L. Sackett.

Appointments Reported

The following appointments, made too late for inclusion in the 1937 Membership List, were reported for record:

To Power Test Codes, Committee No. 8 on Centrifugal and Rotary Pumps, Robert T. Knapp and Robert L. Daugherty.

To Safety Code Correlating Committee, H. H. Judson and Dan L. Royer, alternate.

To National Management Council, L. P. Alford, to fill unexpired term of the late R. I. Rees.

To Board of Directors, A.S.A., P. E. Bliss.

To New Sectional Committee on Building Code Requirements for Light and Ventilation, F. R. Scherer.

To E.C.P.D. Delegatory Committee for Region 3, William S. Monroe.

As representative, award of Washington Medal, Feb. 23, 1937, of Western Society of Engineers, W. L. Abbott.

As representatives, annual meeting, Apr. 16–17, 1937, American Academy of Political Science, George E. Crofoot, J. P. Harbeson, Jr., and Henry S. Harris.

As committee on arrangements for participation in the Discussion on Lubrication and Lubricants, October, 1937, Institution of Mechanical Engineers, G. B. Karelitz, chairman, N. E. Funk, and Crosby Field.

A.S.M.E. Program Planned for the Southern Textile Exposition, April 5–10

THE Greenville, S. C., Section and the Textile Division of the A.S.M.E. are cooperating to present a one-day program on April 7, during the week of the Southern Textile Exposition. A tentative schedule of the events for that day follows:

Registration Opens
9:00 a.m. Hotel Poinsett

Technical Session
9:30 a.m. Ball Room

Presiding Officer, John A. McPherson, vice-president and chief engineer, J. E. Sirrine & Co., Greenville, S. C.

Textile Plant Fire Protection, With Particular Reference to Southern Textile Mills in Which Modernization Programs Are Contemplated, by Asa Hosmer, southern field manager, Factory Insurance Association, Charlotte, N. C.

Production and Utilization of Short-Cut Rayon, by Jos. R. Gill, general manager, American Enka Corporation, Enka, N. C.

Sanforizing, by factory representative of the Cluett-Peabody & Co., Troy, N. Y.

Production of Heat & Power for Industrial Plants, by member of Student Branch, A.S.M.E., Clemson College.

Afternoon:
Visit to Southern Textile Exposition

6:30 p.m.
Dinner (Informal) Club Dining Room, Hotel Poinsett

Toastmaster; Eugene W. O'Brien, vice-president, W. R. C. Smith Publishing Company, Atlanta, Ga.

Utilization of Southern Pine for Paper and Textile Industries, by Charles H. Herty, former president of the American Chemical Society, Herty Research Laboratory, Savannah, Georgia.

Address by J. E. Sirrine, President, J. E. Sirrine & Company, Engineers, Greenville, S. C.

A.S.M.E. Applied Mechanics and Hydraulic Divisions to Meet in Ithaca, June 25–26

THE fifth national meeting of the A.S.M.E. Applied Mechanics Division together with the Hydraulic Division will be held at Cornell University, Ithaca, N. Y., on June 25 and 26. Preliminary plans include sessions on elasticity, fluid mechanics, plasticity, and vibration under the leadership, respectively, of Prof. S. Timoshenko, Dr. H. L. Dryden, Dr. A. Nádai, and F. M. Lewis. Hydraulic Division sessions will be devoted to cavitation under the direction of S. Logan Kerr, chairman of the Division, and C. F. Merriam, of the cavitation committee.

Social activities will include a picnic supper on Friday evening, June 25, at Taughannock Falls State Park on the shores of Lake Cayuga. On Saturday evening a dinner is to be held at Willard Straight Hall on the University campus, with C. R. Soderberg, chairman of the Applied Mechanics Division, in charge.

A cordial invitation to attend this meeting is extended to members of the S.P.E.E. who may be able to stop over in Ithaca on their way to the Cambridge meeting of that Society, scheduled to start on June 28.

Graphic Arts Conference New York, May 7–8

THE A.S.M.E. Graphic Arts Division will cooperate with the Graphic Arts Research Bureau in a Graphic Arts Conference to be held in New York City on May 7 and 8, with headquarters at the Hotel Commodore.

Thursday, May 6, will be devoted to inspection trips of printing and engraving plants in the city. Details on the trips have not as yet been completed but those planned so far include the plants of R. Hoe & Co., and the *New York Daily News*.

The opening session on Friday morning on management will have as its presiding officer John Clyde Oswald, member A.S.M.E. In general, papers will cover the setting of standards and time schedules in the printing industry and training of skilled and semi-skilled workers in graphic arts.

Edward Epstean, president of the Graphic Arts Research Bureau, New York, and member of the A.S.M.E., will be in charge of the luncheon program. A. E. Giegengack, U. S. Public Printer, will be the toastmaster. John H. Finley, editor, *New York Times*, and James H. Herron, President, A.S.M.E. will speak.

In the afternoon a session on progress in the printing of color, in charge of W. C. Huebner, associate A.S.M.E., of the Huebner Laboratories, will consist of a series of short talks by experts detailing progress which has been made in this field.

On Saturday morning there will be a general technical session at which Burt Stevens will preside. Problems in rubber plates, rollers, paper, and quick-drying inks will be discussed.

Secretary Davies Visits South and West

C. E. DAVIES, secretary, The American Society of Mechanical Engineers, leaves on Sunday, March 28, on an extensive visit to sections and student branches of the Society located in the South and West. His trip will carry him to the Pacific Coast and bring him back in time for the Semi-Annual Meeting of the Society to be held in Detroit, Michigan, during the week of May 17.

Mr. Davies' first stop will be at New Orleans, on March 30, where he will address the New Orleans Section and the student branch at Tulane University. The remainder of the itinerary follows:

March 31: Louisiana State University, Baton Rouge, La., and South Texas Section, Houston, Texas
April 1: Rice Institute, Houston, and Texas A. & M. College, College Station, Texas
April 2: University of Texas, Austin, Texas
April 3: San Antonio, Texas
April 5: Oklahoma A & M College, Group VI, Southern Unit, Stillwater, Okla.
April 6: Texas Technological College, Lubbock, Texas
April 7: Colorado Section
April 8: University of Colorado, Boulder, and Colorado School of Mines, Golden, Colo.
April 9: University of Wyoming, Laramie, Wyo.
April 12: Utah Section, and University of Utah, Salt Lake City, Utah
April 13: Boulder Dam
April 14, 15, and 17: Los Angeles Section, Los Angeles, Calif. and University of Southern California.
April 16, California Institute of Technology, Pasadena, Calif.
April 19: University of Santa Clara, Santa Clara, Calif., and Stanford University, Stanford University, Calif.
April 20: San Francisco, Calif.
April 21: University of California, Berkeley, Calif.
April 23: University of Nevada, Reno, Nev.
April 26: Oregon State Agricultural College, Corvallis, Ore.
April 27: Oregon Section, Portland, Ore.
April 28: Western Washington Section, Seattle, Wash.
April 29: University of Washington, Seattle.
April 30: University of Idaho, Moscow, Idaho, and Washington State College, Pullman, Wash.
May 1: Inland Empire Section, Spokane, Wash.
May 2: Grand Coulee Dam
May 3: University of Montana, Bozeman, Mont.
May 4: North Dakota Agricultural College, Fargo, N. D.
May 5: University of North Dakota, Grand Forks, N. D.
May 6: South Dakota State College, Brookings, S. D.
May 7: Minnesota Section, and University of Minnesota, Minneapolis, Minn.
May 10: Duluth, Minn.
May 11: Michigan College of Mining and Technology, Houghton, Mich.
May 12: Milwaukee Section, and Marquette University, Milwaukee, Wis.
May 17: Detroit, Mich.

Metropolitan Junior Group and Student Branches Hold Smoker

REPRESENTATIVES of the Student Branches and the Junior Group of the Metropolitan Section spoke on outstanding phases of their activities at an informal Smoker held at Cooper Union on February 23. Following the talks there was a general discussion of the ideas and problems brought up during the evening.

Each undergraduate who spoke described one type of activity so that a complete picture of the scope of student-branch work in eight colleges was given.

The professional attitude as cultivated by Cooper Union was depicted by Bernard Kleban. Zygemont Jaros spoke on the importance of student papers and the means used at New York University to stimulate interest in their presentation. Increased ability of expression was the aim of Pratt Institute as described by William A. Freer. Robert Buchanan of Stevens Institute of Technology pointed out the advantages of inspection trips both in giving practical instruction and in extending the field of knowledge.

The liberal and cultural side of engineering as it interests the members of the Brooklyn Polytechnic Institute was described by Eugene McLaughlin. He showed the need for a broadening of the engineering student's outlook. Social affairs for the engineers at the College of the City of New York was Samuel Sharko's topic, while Ivor G. James of Columbia University and England presented a comparison of the work of English and American student branches and Joseph T. Bailey of Newark College of Engineering stressed the need for engineers to realize their civic responsibilities.

Briefly describing the A.S.M.E. junior group and its relationship with the student branches and the senior body, Oscar B. Schier, junior-group chairman, indicated the means of development and the opportunities for acquaintainship in the Society.

For the purpose of developing further the contact between the student members and the juniors, Walter W. Lawrence, chairman of the junior group membership committee, invited the Metropolitan Section student branches to a junior group meeting to be held on May 7. Further details will be announced later.

W. W. Nichols Speaks on Junior-Group Work

AN interesting dinner meeting was held by the Junior Group of the Metropolitan Section in Leeds Restaurant on 40th Street, New York, on February 19, at which Mr. W. W. Nichols, a prominent figure in the Detroit Section and an inspirational leader to the Detroit juniors, led a round-table discussion on junior-group work. Mr. Nichols described the activities of the Detroit Section Junior Group and made many valuable suggestions applicable to the Metropolitan Section. He told how many of the older men in Detroit invite a score of junior members to their homes for informal get-togethers to promote acquaintanceship, a custom he commended most heartily.

For the individual, he advocated broad interests in all types of engineering, thoroughness in every endeavor, and the development of leadership.

This was the first dinner meeting of the group and those attending enjoyed entering into the discussion. More meetings of this general type are planned since this one proved of so much interest.

With the Student Branches

Talks by Student Members

NORTH DAKOTA STATE BRANCH listened to papers by Maynard Walberg on bakelite, Merlin Huson on Diesel-engine operation, and Harold Sundfor on Diesel and gasoline-engine combustion-chamber design. . . . Out at OKLAHOMA A & M, Wilford Maxey talked on pulverized fuels. . . . The members of IOWA STATE BRANCH learned about the making and flying of model airplanes from James Brandt. Jack Power followed him with an interesting discussion on the ancient pastime of whittling. Lowell Haas traced the present and future development of rocket ships. Wright Gannett showed samples of his model-railroad building skill, and Don Arp explained the making of metal lath. . . . Robert Neff presented before the IOWA BRANCH a paper on the various methods of drawing glass. Robert Clarke discussed natural gas. . . . SOUTH DAKOTA STATE BRANCH members joined with a great deal of interest in the discussion about the relative technical merits of the three most popular cars. Hokanson presented the case for the Plymouth, Gordon for the Ford, and Foster for the Chevrolet. . . . KANSAS STATE BRANCH limits the presentation of papers by student members to 15 minutes each. J. S. Dukelow spoke on air conditioning for small residences, Mac Kappleman talked on automobile streamlining, and Clarence Nielsen gave a fine paper on portland- and rubber-cement binders for foundry cores. . . . ARKANSAS BRANCH listened to a seminar paper by Paul Hoffman on cooling towers which he illustrated with actual photographs. . . . COLORADO

"STEAM MEN'S STRUT"
(Washington University Student Branch, Jan. 20, 1937. Story on page 309.)

BRANCH members heard all about the purpose, organization, construction, and history of Randolph Field in Texas from Elston Gardner. Gordon Wolcott gave a talk on cotton ginning based on his own personal experiences in the industry. . . . COLORADO STATE BRANCH had Harold Standley give an illustrated lecture on the life of Steinmetz. . . . BROOKLYN POLYTECHNIC BRANCH had talks on homing pigeons by Maystrik, cosmic rays by Savitsky, and electron tubes by McFarland. . . . At the LOUISVILLE BRANCH, R. W. Lovelace presented a paper on television. . . . The following talks were presented at IOWA STATE BRANCH: layout and construction of steel tanks and boilers by Trigg, mercury boilers by May, and a comparison of aluminum and stainless steel in aircraft design by Forestner. . . . Papers were given at RICE BRANCH by M. H. Greenwood on design trends in transport planes, W. Liljestrand on welding of aluminum alloys, Fred Briggs on marine-turbine installations, H. B. Young on Diesel fuels and E. W. Keating on high-altitude flying. . . . TORONTO BRANCH had eight papers presented at one meeting. Members of the local section of the A.S.M.E. acted as judges. Ian M. Haner took first place with his paper on aeroplane skiis, Carriere was second with a paper on the compression-ignition engine in railroad service, and Malcolm took third place with his talk on the rear-engined automobile.

Joint Meetings

WISCONSIN BRANCH had a joint meeting with the student branch of the American Society of Agricultural Engineers at which the Grand Coulee Dam motion picture was shown. . . . NEW HAMPSHIRE BRANCH members got together with the A.S.C.E. student branch and viewed motion pictures of the construction of the George Washington Bridge in New York. . . . NORTH CAROLINA BRANCH acted as host to NORTH CAROLINA STATE and DUKE BRANCHES at a joint meeting held at Chapel Hill. J. A. Miller talked on highway safety, Hyde and Cate explained the valve system of a Fitchburg uniflow engine which is operated in the school's laboratory. . . . TULANE BRANCH was host to the LOUISIANA STATE BRANCH at a joint meeting. After the meeting, inspection trips were made to a cement plant and an electric power plant. . . . IOWA STATE BRANCH presented T. A. March, member of the A.S.M.E., who showed colored motion pictures on coal feeding and burning. A.S.C.E. student branch members were the guests of the M.E.'s at this very instructive and interesting lecture.

Trips and Inspections

STEVENS BRANCH members were guests of radio station WOR in an inspection trip through the transmitting plant at Carteret, N. J. . . . RICE BRANCH sponsored an inspection trip to a salt mine at Hockley, Texas. After looking over the salt crushers and screening equipment, the student engineers were lowered nine at a time in salt buckets into the bowels of the earth.

Interesting Talks by Outsiders

Dr. Felix Isermann is still with us traveling from school to school, explaining the mechanical equipment produced in Germany and the coming Leipzig Fair. From last reports, he has also visited ARMOUR, PITTSBURGH, and MICHIGAN BRANCHES. . . . MICHIGAN STATE BRANCH had the good fortune to have, as guest speaker, Prof. Walter Rautenstrauch who lectured on the "Economic Characteristics of Some American Industries." . . . STANFORD BRANCH had talks presented by two faculty members. Professor Jacobsen spoke on "Vibrations in Kinetic and Elastic Dynamics" and Professor Timoshenko spoke on the "History of Applied Mechanics." . . . GEORGE WASHINGTON BRANCH learned a great deal from William M. Swanger of the U. S. Bureau of Standards about the organization's work. One of the most interesting features of his talk was the explanation of how the Bureau takes broken parts from an airplane or railroad wreck and after a detailed examination, determines if the cause of the wreck was due to structural failure. . . . ARMOUR BRANCH got first hand information about A.S.M.E. activities and student branches from Ernest Hartford, the popular student activities director of the A.S.M.E. . . . OKLAHOMA BRANCH members were told about "Photographic Study of Fluid Flow" by Prof. E. E. Ambrosius. . . . Maxwell C. Maxwell presented his very interesting talk on locks, entitled "Loxology," before the NEBRASKA BRANCH. . . . Herbert McAnich, a former student member of ROSE POLYTECHNIC BRANCH talked to his former associates on the analysis of stresses with polarized light. According to our informant, Frank Blount, a very interesting and spirited discussion followed the presentation of the paper. . . . Prof. Bradford, an OHIO STATE M.E. graduate of 1883 and now school architect, presented an illustrated talk with lantern slides before the student branch on the school's buildings and equipment from its founding to the present day interspersed here and there with anecdotes of life on the campus. . . . At another meeting, STANFORD BRANCH had graduate member Robert Jeffrey present a paper on a new type of carburetor which he designed and built. He calls it the D-J carburetor. It differs from others in that it has neither a float chamber nor a fuel jet. The proper air-fuel ratio is delivered by utilizing the intake manifold air pressure.

A.S.M.E. Student Conferences for 1937

Groups		Places	Dates	Hosts
I	New England	Providence, R. I.	April 23–24	Brown University
II	Eastern	New Brunswick, N. J.	April 19–20	Rutgers University
III	Alleghanies	Columbus, Ohio	April 26–27	Ohio State University
IV	Southern	Chattanooga, Tenn.	April 19–20	Chattanooga Local Section
V	Mid West	Chicago, Ill.	April 19–20	Northwestern University
VI	Northern Unit	Kansas City, Mo.	April 9–10	Kansas State College
VI	Southern Unit	Stillwater, Okla.	April 5–6	Oklahoma A. & M. College
VII	Northwest Unit[1]	Pullman, Wash.	April 19–20	State College of Washington
		Moscow, Idaho	April 19–20	University of Idaho
VII	Central Unit	Laramie, Wyoming	April 23–24	University of Wyoming
VII	Southwest Unit	Stanford Univ., Cal.	April 1–3	Stanford University

[1] This meeting being held under joint auspices at both campuses.

Tiny Chips From Here and There

North Dakota State reports that the entire senior class is represented in the A.S.M.E. Student Branch. . . . Colorado Branch had R. F. Throne, of the Public Service Co. of Colorado, talk on the company's operations, troubles incident to the operation and maintenance of transmission lines, economic problems involved in company expansion and interesting details about the equipment recently installed in the Valmont power plant. Donald Risley, secretary of the branch, reports that at this meeting there were present to listen to Mr. Throne, 21 of his fellow engineers from the company. . . . Louisiana State Branch has recommended to the university's faculty the installation of the "honor system" in the engineering school. . . . At Texas Tech Branch, Max Nuttall compiled a list of names and addresses of prospective members grouped in zones according to place of residence. He then designated a committee for each zone whose duty it was to contact the men in its particular zone regarding membership in the A.S.M.E. student branch. . . . C. C. N. Y. Branch is taking an active interest in the work of a recently formed "Engineering Alumni Committee on Employment." Each member has contributed one dollar to help defray organization expenses of the committee. . . . Newark College Branch has had many freshmen voice a desire to join the branch. Other branches throughout the country have taken advantage of this situation by evolving plans of associate membership for sophomores and freshmen thereby deriving a financial benefit out of the dues collected from these men. The Committee on Relations With Colleges at its December meeting advocated plans of this nature. Additional information can be obtained from Mr. Hartford. . . . Nebraska Branch in connection with the short Diesel course presented at the university over a period of three weeks, sponsored three meetings as part of the program. Engineers from the Caterpillar Tractor Co., Waukesha Motor Co., and Hercules Motor Corporation were obtained to give the lectures at these meetings.

The Professor Is Puzzled

Professor Charles L. Allen, honorary chairman of Pennsylvania State Branch, can't understand the reason why almost 300 students attended a very little publicized meeting of the branch at which motion pictures about the construction of Ford cars and international Diesel engines were shown. The walls of the M.E. lab, where the pictures were shown, almost bulged outward because of the crowd jammed within its confines. Maybe the solution to the professor's problem lies in the great spirit and activity shown throughout the year by the 60 or more members, chairman A. M. Krakower and secretary Henry Taylor in furthering the work of their branch.

Washington Branch Holds Dance in Engine Laboratory

Washington Branch held a dance on January 29 in the school's engine laboratory. The dance was called the "Steam Men's Strut" and every one was dressed in overalls or other suitable attire. The lab was decorated with colored lights and a ping-pong table was set up in the adjoining pattern shop. Besides dancing to the "mechanical music" of an amplifying system, the girls and boys had community singing and played ping-pong, hop scotch, and other such games.

Other Engineering Activities

Golden Jubilee of Canadian Engineering

On June 15–18, The Engineering Institute of Canada will celebrate the semicentennial of its founding. Technical papers and discussions will be presented at the Windsor Hotel, Montreal, on the first two days of the meeting with visits to points of technical and general interest in and around the city on the next day. The morning of the last day will be occupied in traveling to Ottawa, and the afternoon will be devoted to similar visits there. On the day after the conclusion of the meeting, the offices at Ottawa of the government departments dealing with engineering will be open for inspection, and, during the next week, the branches of the Institute at Hamilton, Toronto, Niagara Peninsula, and other centers will organize visits to plants and places of interest in their vicinity.

The meeting will be definitely international in character. Papers by members of the Institutions of Mechanical, Electrical, and Chemical Engineers will be presented as well as others by members of the Institute. Official delegations from many engineering societies in Great Britain and the United States are expected to attend the sessions.

Lubrication and Lubricants to Be Discussed by I.M.E.

From the Institution of Mechanical Engineers comes a preliminary notice of a "General Discussion on Lubrication and Lubricants," to be held in London toward the end of October, 1937. It is proposed that the discussion occupy a period of two days and center around a series of about 100 papers to be invited from leading authorities throughout the world.

The American Society of Mechanical Engineers has been invited to cooperate in the discussion by nominating authors to participate in the sessions. An A.S.M.E. Committee on Participation has been formed, consisting of G. B. Karelitz, of the Lubrication Research Committee, who will act as chairman, and Nevin E. Funk, of the Research Committee, and Crosby Field, of the Committee on Professional Divisions.

The proposed program has been arranged in four groups: (1) Journal and thrust bearings; (2) engine lubrication, with sections on internal-combustion and reciprocating steam engines; (3) industrial applications, with sections on lubrication of antifriction bearings, gear lubrication, and miscellaneous applications; and (4) properties and testing.

M.I.T. Summer School on Strength of Materials

A special summer school and series of conferences on the strength of materials will be held at Massachusetts Institute of Technology, Cambridge, for four weeks, June 21 to July 16. Creep, fatigue, and strength of materials will be covered in a series of lectures by specialists and members of the Institute faculty, which will be supplemented by laboratory exercises. Four seminars will be held during the course to afford opportunities for presentation of recent developments in allied fields of engineering mechanics, and the course will be concluded by all-day conferences on creep and fatigue.

Credit for nine units of advanced study will be allowed for the satisfactory completion of this course. Admission to the summer school will be in the order of application, and all registrations must be made prior to June 1.

New England Foundry Conference, April 9–10

Massachusetts Institute of Technology, Cambridge, will be host on April 9 and 10 to a foundry conference which is being sponsored by the American and New England Foundrymen's Associations and the Institute. Technical sessions will be held in the morning and the afternoon of each day, with a dinner meeting on the evening of April 9, at which a lecture on high-speed photography will be given. Papers dealing with the design of iron, steel, and nonferrous metals castings; physical testing of cast metals; molding sand; sand-testing technique; and cupola operation, supplemented by demonstrations in some cases, are scheduled for presentation.

John Scott Medal Awarded to Langmuir

For his physical and chemical discoveries resulting in improved gas-filled incandescent lamps, Dr. Irving Langmuir, associate director of the General Electric Research Laboratories, Schenectady, N. Y., and recipient of the A.S.M.E. Holley Medal in 1934, was recently awarded one of the John Scott medals by the Board of City Trusts of the City of Philadelphia. These medals are the result of

a bequest which was made by John Scott, a chemist of Edinburgh, Scotland, to the City of Philadelphia in 1816, and are awarded annually to "ingenious men and women who make useful inventions."

Erskine Ramsay Awarded Saunders Medal

ERSKINE RAMSAY

THE William Lawrence Saunders Medal for 1937 has been awarded to Erskine Ramsay, chairman of the board, Alabama By-ProductsCorporation, Birmingham, for distinguished achievement in mining. This is an annual award of the American Institute of Mining and Metallurgical Engineers, and the medalist is selected by a continuing committee of 17 members who are nominated by the president and chosen by the board of directors of the Institute.

Mr. Ramsay was born in a Pennsylvania coal-mining community but has lived in Birmingham since 1887 and is regarded as the dean of the mining fraternity in the Southeast. Of the 11 recipients of the medal since its establishment in 1927, he is the third member of the A.S.M.E. to be thus honored.

Conference on the Teaching of Mechanical Engineering

THE mechanical-engineering division of the Society for the Promotion of Engineering Education will hold a conference on June 28 and 29 in Cambridge, Massachusetts, to consider various phases of the teaching of mechanical engineering. This conference will precede the annual meeting of the S.P.E.E. which will be held from June 29 to July 2 with Massachusetts Institute of Technology and Harvard University as hosts. Further details of the conference will be announced later. Prof. Frank L. Eidmann, Columbia University, is chairman.

Lincoln Gold Medal for Best Paper on Welding

TO STIMULATE the preparation of worthwhile contributions to the art of welding, a gold medal will be presented to the author of the best paper on any phase of welding published in *The American Welding Society Journal* for the year ending October, 1937. A committee of three will be appointed to make the award, and the medal, which has been named the Lincoln Gold Medal in honor of the donor, J. F. Lincoln, president, Lincoln Electric Company, will be presented at the Fall Meeting, Oct. 18–23, 1937.

In making the award, the committee will consider papers presented before any Section of the American Welding Society or at the Society's Fall Meeting. No restrictions are placed on the subject matter of the paper, which may be on electric-arc, gas, resistance, or any form of welding coming under the scope of the Society. To be considered for the medal, papers must be received by the editor of the *Journal* before Sept. 15, 1937.

Johns Hopkins Honors Compton and Thomas

AT THE celebration on Feb. 22, 1937, of the twenty-fifth anniversary of the founding of the Johns Hopkins School of Engineering, Karl T. Compton, member, A.S.M.E., president, Massachusetts Institute of Technology, who delivered the principal address of the day, was presented with the honorary degree of doctor of laws. Carl Clapp Thomas, member, A.S.M.E., first professor of mechanical engineering at the school and at present vice-president of the Dwight P. Robinson and Company, Inc., Pasadena, Calif., received the honorary degree of doctor of engineering.

In a series of papers read at a technical session two other A.S.M.E. members were represented. A. G. Christie presented a paper entitled "Progress in Power Development," and J. C. Smallwood one on "Modern Oil Burners."

Nominations for A.I.E.E. Officers

THE following list of candidates for offices in the American Institute of Electrical Engineers for the next administrative year has been submitted by the national nominating committee: President, W. H. Harrison; vice-presidents, I. M. Stein, E. D. Wood, L. N. McClellan, J. P. Jollyman, and M. J. McHenry; directors, C. R. Beardsley, V. Bush, and F. H. Lane; treasurer, W. I. Slichter.

These candidates will be voted upon by the membership and the results of the balloting will be announced at the annual business meeting of the Institute which will be held at Milwaukee, Wis., June 21. The officers will enter upon their duties on Aug. 1.

Three of the nominees, Messrs. Bush, Lane, and Slichter are members of the A.S.M.E.

A.E.C. News From Washington

A.E.C. Comments on Industry Legislation

INDUSTRY legislation designed to effectuate the recommendations of the joint management-labor Council for Industrial Progress or to revive something like the NRA is still nebulous but is receiving much consideration. Just what device will be used to bring about control of hours, wages, and unfair competition remains very much open to question, but those "who know" claim that the President will lend his support to some one of the many plans now in the process of development. Of the more favored objectives, we find: Federal aid to small business enterprises; a permanent economic advisory commission; establishment by law of maximum hours of work and minimum wages in industry; abolition of child labor; and prevention of unfair methods of competition. The exact formula depends on many factors, but "close advisers" seem to think that these are the main ideas. One of the bills submitted proposes federal insurance of loans to small enterprises made by banks and other private lending institutions. A second measure seeks to establish a Federal Economic Advisory Commission to aid in the stabilization of employment in industry, agriculture, and commerce. Another piece of legislation proposes that legal regulations on hours, wages, child labor, and competitive practices be premised upon the fact, to be established by legislative findings, that sweated labor and unemployment of children in industry, constitute unfair methods of competition in commerce.

Another proposal would enlarge the Federal Trade Commission to nine members so constituted as to provide equal representation of the public interest, management, and labor in the same administrative agency. It would give the Trade Commission power to approve agreements for affirmative and cooperative action by groups in industry. Approval of such agreements by the Commission would exempt the parties from penalties under antitrust laws. Any person could apply to the Commission for exemption from the provisions of the act on the ground that his business operations were interstate.

Indiana Organizes a State Engineering Council

PRESIDENT A. A. Potter of American Engineering Council, speaking before the joint meeting of the Indiana Engineering Society and the local sections of the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and the American Society of Civil Engineers on Feb. 16, 1937, advocated the coordination of state engineering societies and local sections through the formation of a State Engineering Council. Dean Potter outlined some of the distinctive opportunities of such an organization as follows: An advisory committee or group of committees on public affairs—dealing with such questions under proper subcommittees as improved state maps, con-

servation and utilization of water resources, state public works, engineering education, licensing, state industrial development, utility services, and special legislation in the public interest.

Under a second broad heading of "Programs for United Action of Member Organizations," he suggested such topics as the merit system in state service, and publicity.

"A State Engineering Council," said Dean Potter, "acting for the profession in matters of special concern to a state, is in a position to serve the engineer as well as the public more effectively if it can present a united front for all engineering groups of a commonwealth and if it keeps before the public the significance of engineering services to the public. The State Engineering Council, while working for the unification of all engineers in viewpoint, thought, and action, must not interfere with the specialized fields or with the autonomy of the groups it serves. It is not expected to manage but to coordinate and represent engineering thinking in any state in the interest of the public."

At the meeting, the formal organization of the Indiana State Engineering Society as the "Indiana State Council of Engineers" was completed.

A.E.C. Acts on Patent Situation

IN ALL of the flurry of patent legislation in recent years, the American Engineering Council's alert Patents Committee has kept closely in touch with the situation and has acted in the interest of engineers and the public in those cases where opportunity was found to improve patent court conditions and patent-office procedure. Of most importance are actions taken on the porposed Court of Patent Appeals and legislation affecting pooling and cross licensing.

The Committee has recommended that the Council support legislation for a single Court of Patent Appeals, and the A.E.C. Assembly has approved the recommendation and has taken the position that it will look with favor upon the idea of having the judges named to such court selected by the President and confirmed by the Senate only after careful review of their special and technical competence with the advice of engineering and scientific societies as well as the advice of the patent bar and the legal profession.

Scientific advisers to the courts have been recommended by a number of agencies, but not all with the same purpose. Most often quoted is the suggestion of a special patents committee of the Science Advisory Board. That committee recommended that scientific advisers be made available to aid *trial* court justices. In this conclusion, the committee agrees with the recommendations of the special patents committee of the Science Advisory Board. The Patents Committee looks with some favor on such an idea if a suitable method of selecting advisers free from preconceived opinions were fixed and if a sufficiently diversified list of skilled scientific and engineering talent were made available. However, the committee has doubted the wisdom of having such scientific advisers named permanently as a part of a new single Court of Patent Appeals. It feels that the idea of naming three such advisers who would serve for all classes of cases would not afford such highly skilled aid in all divisions of science and technology as courts really require.

The committee feels that the public interest has been much more served than harmed by patent pools and by cross licensing. Such evils as may have been experienced would not have been corrected by any of the proposed forms of legislation. The committee feels that administration of present laws, including proper and reasonable application of anti-trust legislation, would suffice to correct those types of evils of pooling which have been disclosed or charged as bad practice.

The American Engineering Council has also approved the Patents Committee's recommendation to oppose all of the various types of proposals which would restrict the freedom of owners of patents to use them constructively under present laws. It regards such offenses as are now charged against the patent system as the result of defects in administration of present laws and not as evidence of the need of more legislation.

The committee believes that every effort should be made by industry as well as by the engineering profession to increase the presumption of validity of patents as issued. It feels that engineers generally should assist patent examiners whenever possible to keep abreast of the arts with respect to which they are examining patent applications. The committee has not found any legislation, proposed to date, sufficiently constructive to feel that it deserves support of the American Engineering Council. It does, however, hope that some means may be developed for increasing the standards of competence and experience of the staff of examiners in the Patent Office.

The staff is following legislation for the Court of Patent Appeals in S.475 introduced by Senator McAdoo of California, and the Patents Committee is giving further consideration to such matters as technical advisers to the courts, patent pooling and cross licensing, compulsory working and licensing, automatic validation of patents five years after issue, and taxation during nonuse.

A.E.C. Unites Opinion on Rural Electrification

IN ITS unbiased approach to the subject, American Engineering Council's Rural Electrification Committee seems to have made a real contribution toward a better understanding of the practical uses of electricity on the farm and toward a meeting of private and public minds on sound practices in rural electrification. The American Engineering Council's Rural Electrification Committee's Report for 1936 was referred to by Mr. Morris L. Cooke in a letter to the editor of the *New York Times* entitled "Rural Electrification," which was printed in the Feb. 1, 1937 issue of the *Times*. Mr. Cook is also reported to have publicly referred to the report as representing an excellent approach to rural electrification.

Utilities and private industry have also sought copies of this report in a complimentary sense. All criticism received has been constructive and directed toward improving the recommendations for increasing the use of electricity on the farm and making the use pay dividends to the farmer in health, time saving and economy. Other suggestions have to do with ways and means to make rural distribution systems pay their own way, and with the construction of rural lines of the lowest cost consistent with quality and service.

The A.E.C. Rural Electrification Committee made five recommendations with the ultimate well-being of citizens in rural life as the final objective: (1) Every farmer who can use electricity economically should be supplied with it, (2) service should be supplied in the most efficient and dependable manner and at the lowest cost consistent with quality and service; (3) each farm operator should be informed as rapidly as possible regarding the electric power and equipment needs of his own individual farm; (4) each farmer should be informed as rapidly as possible regarding the best ways of using this power and equipment so that the greatest economy may be effected; (5) every effort should be made to develop new equipment and processes whereby electric power can be used to bring the farmer closer to his market, whether he is selling food products or raw materials of industry.

In conclusion, the report advances the opinion that such a program of rural electrification will require the utmost cooperation between all branches of the agricultural and engineering professions, and all agencies, public and private, that are involved in this development. The problem is a tremendous one, but its solution will go far in helping solve the economic problems of American agriculture, and indirectly the economic problems of the nation.

Carmody Replaces Cooke on R.E.A.

RURAL Electrification Administration news is the resignation of Administrator Morris L. Cooke. Mr. Cooke is reported to have resigned voluntarily to seek a rest from the burden of responsibility which the President drafted him to carry from the creation of the Rural Electrification Administration. An interesting rumor in connection with Mr. Cooke's resignation is the unofficial report that his friendly consideration of the interests of privately owned utilities added to the burden of his responsibility and engendered trying misunderstandings among his liberal colleagues.

John M. Carmody, member, A.S.M.E., an editor and industrial engineer, formerly a member of the National Labor Relations Board, chief engineer of C.W.A. and F.E.R.A., with much experience in the railroad, steel, and coal industries and in private practice, succeeded Mr. Cooke. He is being assisted by Col. George D. Babcock, of North Carolina,

who was associated with Mr. Carmody in the other emergency agencies.

At the conclusion of Mr. Cooke's administration, R.E.A. had lent or earmarked a total of over $50,000,000 for 257 rural electric projects to serve 165,000 rural customers in 40 states and Alaska. These figures do not include funds involved in contracts providing that the Electric Home and Farm Authority cooperate with both public and private utilities in financing the sale of electrical appliances for use by consumers located on public- and private-utility power lines.

In spite of differences of opinion regarding public and private utilities and rural electrification, a very pleasant relationship exists between the American Engineering Council and the R.E.A. The A.E.C. Rural Electrification Committee's report for 1936 was referred to by Mr. Morris L. Cooke in a letter to the editor of the *New York Times* entitled "Rural Electrification" which was printed in the February 1, 1937, issue of the *Times*. Mr. Cooke is also reported to have publicly referred to the report of the A.E.C. Rural Electrification Committee as representing the best approach to rural electrification. Council's staff knows Mr. Carmody and his assistants, and hopes to also be of service to them in all that they may actually do to advance the public welfare.

A.E.C. Cooperates With National Resources Committee

NATIONAL Resources Committee has released the minutes of a joint meeting of its Water Resources Committee with the Committee on National Water Policy of the American Society of Civil Engineers, the American Water Works Association, Conference of State Sanitary Engineers, and the American Engineering Council held in the Interior Building on Sept. 22, 1936. A limited number of copies may be obtained from the Publications Section, National Resources Committee, Interior Building, Washington, D. C. Although this meeting was primarily for the exchange of information and opinion, it covered a wide range of such subjects as basic hydrologic data, Rio Grande joint investigation, drainage-basin study, drainage and water-storage programs, flood and flood-control investigations, small water-storage projects, western water problems, water-works statistics, water and stream pollution, and the general program of the Water Resources Committee of the National Resources Committee. Engineers interested in these subjects will appreciate the spirit of cooperation exhibited in this meeting.

Council cannot afford to make a general distribution of the National Resources Committee's report on Public Works Planning issued in December, 1936, but engineers who are interested in long-range public-works programs may obtain a copy and study the background for the five billion dollar public-works plan submitted to Congress by President Roosevelt as a bulkwark against a new depression. It recommends: (*a*) Formulation, adoption, and annual revision of a six-year program of federal construction, (*b*) adoption and annual revision of a proposed list of projects; (*c*) a lump-sum annual appropriation under regular budget procedures for expenditure on approved projects; (*d*) an allocation of these funds to appropriate construction agencies by a permanent public-works or development agency.

John C. Page Appointed Commissioner of Bureau of Reclamation

ON January 25, President Roosevelt appointed John C. Page, a member of the American Society of Civil Engineers, Commissioner of the Bureau of Reclamation to succeed the late Dr. Elwood Mead, long-time Commissioner of Reclamation. Page is a Westerner intimately acquainted with the problems of conservation and the use of the meager water supply of the semiarid and arid states.

Dr. Mead called Mr. Page to Washington Oct. 1, 1935, to assist him in the Commissioner's office as Chief of the Engineering Division. Shortly after the death of Dr. Mead last January, Secretary Ickes appointed Mr. Page, the man Dr. Mead had chosen as his understudy, as temporary head of the Bureau of Reclamation.

Mapping Is Public Works

THE A.E.C. Surveys and Maps Committee is actively supporting a number of efforts being made to advance the basic-mapping program and is making a special effort to educate members of Congress and state planning bodies as well as engineers and all other citizens regarding actual need for adequate maps as a more intelligent basis for planning and the construction of public works.

As a move in the right direction, American Engineering Council has accepted, in principle, the recommendations made by Secretary Ickes in response to Senate Resolution 281, which requested a program for expediting the topographic mapping of the United States. The recommendations involve a 20-year program and the expenditure of $100,000,000. They would give the Geological Survey $4,000,000 for topographic surveys and maps, and the Coast and Geodetic Survey $1,000,000 for first- and second-order control surveys in 1938 under such items as the directors of the surveys may designate

Engineers' Embassy Service

IN THE future, the Engineers' Embassy Service of the American Engineering Council, Washington, D. C., is to be a staff function to transmit engineering points of view and resolutions to public bodies and the executive and administrative heads of the several arms of government service. It will also provide member organizations with an information service in Washington and advise members of member organizations who visit Washington regarding effective contacts among government agencies.

Within the limitations of staff and facilities, the A.E.C. will endeavor to provide effective contacts within government agencies and factual information and unbiased interpretations of legislation and government regulations. Its functions will be purely advisory, however, and cannot be used to exert pressure or exercise lobbying influence.

Alfred D. Flinn, Director, Engineering Foundation, Dies, March 14

ALFRED D. FLINN

FOLLOWING a long illness, Alfred D. Flinn, director, Engineering Foundation, and secretary from 1918 to 1934 of the United Engineering Societies Trustees, died of heart disease on March 14.

Mr. Flinn's engineering career was spent in water-supply and waterworks engineering. From 1895 to 1902 he was connected with the Massachusetts Metropolitan Water Works, Boston, principally with the Wachusett and Sudbury systems, and from 1905 to 1918 with the Board of Water Supply, New York, on engineering and economic studies of the Esopus and Schoharie Watersheds. From 1902 to 1904 he served as managing editor of *The Engineering Record*.

Mr. Flinn, whose engineering achievements were recognized in 1932 by his alma mater, Worcester Polytechnic Institute, by the granting of the degree of doctor of engineering, was also honored by the University of Louvain at the celebration of its 500th anniversary in 1927 with the degree of doctor of applied sciences. He was a Knight of the Order of the White Lion, Czechoslovakia, and member of many engineering and honorary societies.

Mr. Flinn contributed frequently to the technical press throughout his career and was compiler, with R. S. Weston and C. L. Bogert, of "Waterworks Handbook." As director of the Engineering Foundation Mr. Flinn aided in developing and financing such projects as a fatigue of metals research, an investigation of arched dams, alloys-of-iron research, and the work of the Education Research Committee. Until recently he served as secretary of the John Fritz Medal Board of Award and the Daniel Guggenheim Medal Fund, Inc.

Mr. Flinn became secretary of the Engineering Foundation in 1917 and director in 1922. He relinquished his position as secretary of the United Engineering Trustees, Inc., in 1934, because of failing health, but retained directorship of the Engineering Foundation up to the time of his death.

(*Continued on page 314*)

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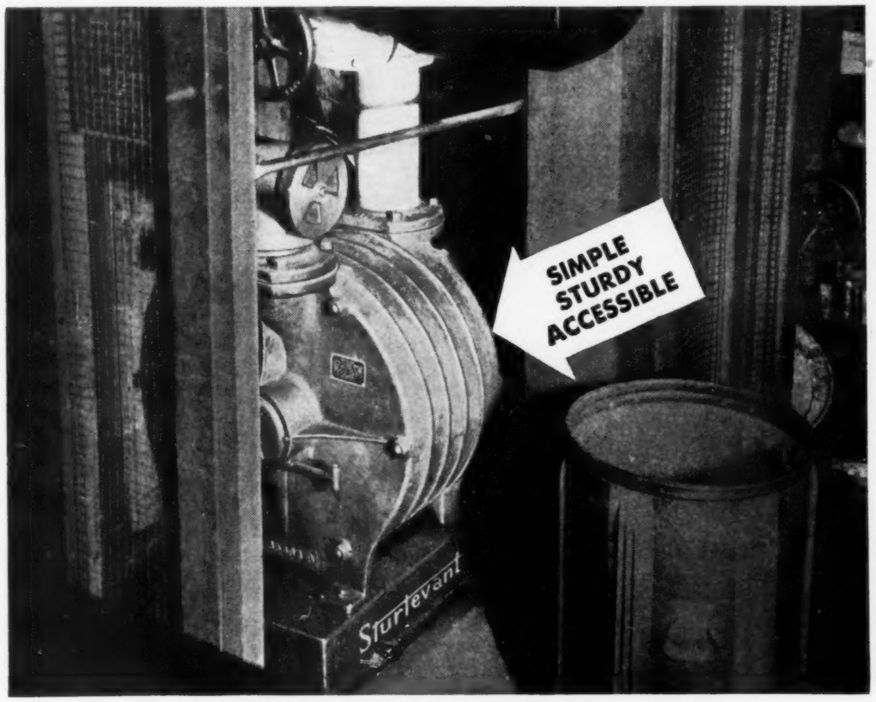

The above Sturtevant Pressure Blower furnishes air for a small furnace, an oil burner, and for blowing out waste material in punching machines.

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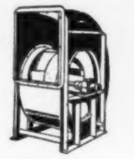
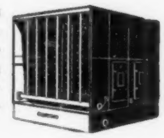


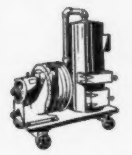
Centrifugal and propeller types. For ventilating, fume removal, and all other purposes. Acid Resisting Fans. High Pressure Blowers.

Air Washers

Made in several types and wide range of capacities to meet varying requirements in cleaning, cooling, dehumidifying, and humidifying air.



Vacuum Cleaners



Used for removing dangerous dust and for general cleaning purposes. Assure speedy, thorough cleaning and effective disposal of dust and dirt. Portable types and central systems.

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Individual units of equipment or complete central systems for maintenance of desired temperature and humidity in industrial air conditioning.

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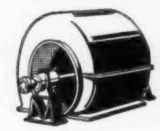

Forced and Induced Draft Fans; Air Preheaters; Water Economizers; Steam Turbines; Reduction Gears. Complete units . . . undivided responsibility.

Power Roof Ventilators

Electric motor driven. Equipped with a powerful, efficient fan wheel which does a real ventilating job. Can be built of acid-resisting metals if necessary.

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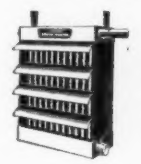

In types for ceiling, wall, or floor installation. Widest and most varied range of capacities available up to 1,500,000 B.T.U.

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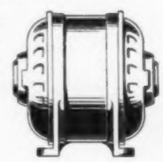
AC and DC. Fraction and integral horsepower sizes. For general purposes and special applications.



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Positions Available

Engineering Societies Employment Service

MERCHANDISE SALES MANAGER, mechanical engineer. Must be experienced in modern sales methods. To take charge of planning, advertising, handling agencies, and salesmen. General knowledge of large industries desirable. Applicant must have qualifications to justify salary of $6,000–$12,000 a year. Apply by letter. Location, New York, N. Y. Y-676.

POWER ENGINEER, graduate mechanical engineer, 30–35, with experience in modern steam equipment, heat balance, use of steam, etc. Salary, $400 a month. Apply by letter. Location, South. Y-994.

ENGINEER to make calculations. Must have experience in valve and valve-fittings industry; also piping in oil industry. Salary, $3500–$4000 a year. Apply by letter. Location, New York, N. Y. Y-1003.

PLANT MANAGER, about 40. Should know pulping business and also have knowledge of resin and resin impregnation. Must have experience in plant management, machinery layouts, etc. Apply by letter. Location, Middle West. Y-1014.

EDITORIAL WRITER, mechanical engineer to write technical and semitechnical articles for manufacturing company for publication in trade journals. Should also be experienced in catalogue work and have had five years' editorial experience. Apply by letter. Location, East. Y-1021.

MANUFACTURING ENGINEER, not over 40, for planning and manufacture of all small machine-made parts. Must have practical experience with lathes, milling machines, etc. Should also have knowledge of metal finishes, etc. Salary, $65 a week. Apply by letter. Location, East. Y-1047.

SALES MANAGER, 30–35, mechanical engineer with experience in power-plant operation and routine office work. To start, actual work will be direction of general sales correspondence in home office, quotations on blow-off valves, water columns, gages for all power-plant conditions, sprayponds, etc. Later work will be in sales promotion. Salary, $3000–$4000 a year with opportunity of participating in bonus. Apply by letter. Location, East. Y-1085.

PLANT SUPERINTENDENT for steel-products division employing about one thousand persons and manufacturing steel stampings of all types including automobile rims and wheels. Must be thoroughly experienced in handling labor and labor problems, as well as familiar with other phases of general factory management. Should have proved record of accomplishment in this field. Salary, $6000–$7000 a year. Apply by letter. Location, Middle West. Y-1099C.

GRADUATE MECHANICAL ENGINEER, not over 40, American, to act as assistant in development department of plant manufacturing liquid-measuring devices and other equipment. Must have experience in design and development of hydraulic devices such as meters and pumps, and must be qualified thoroughly to work out projects and bring them to successful conclusion. Production experience would be helpful. Must be able to work well with others and have executive ability. Only resident of East will be considered. Apply by letter giving complete information including salary requirements and enclosing small photograph. Location, New England. Y-1122.

(*Continued on page 316*)

THE SAN FRANCISCO-OAKLAND BAY BRIDGE, NOW ON THE EVE OF OFFICIAL OPENING TO AUTOMOBILE TRAFFIC, IS ABOUT TO TAKE ITS RIGHTFUL PLACE AS ONE OF THE OUTSTANDING ENGINEERING ACHIEVEMENTS OF ALL TIME.

IN RECOGNITION OF THIS EVENT AND OF THE ENGINEERING GENIUS THAT BROUGHT IT TO PASS, WE, THE ENGINEERS OF AMERICA, AS REPRESENTED BY THE SAN FRANCISCO LOCAL SECTIONS OF THE FOUR FOUNDER SOCIETIES OF AMERICAN ENGINEERING, DO HEREBY RECORD OUR APPRECIATION OF AND OUR FRATERNAL CONGRATULATIONS TO ALL THE ENGINEERS INVOLVED IN THIS MONUMENTAL UNDERTAKING. IN PARTICULAR, WE WOULD THIS DAY, NOVEMBER 5, 1936, ADDRESS OUR TRIBUTE OF COMMENDATION AND PRAISE:

TO THE HOOVER-YOUNG COMMISSION, WHO SO CAREFULLY CHARTED THE PRELIMINARY COMBINATIONS FOR A SUCCESSFUL BEGINNING;

TO CHARLES H. PURCELL, CHIEF ENGINEER OF THE CALIFORNIA STATE HIGHWAY COMMISSION, WHOSE ADMINISTRATIVE ABILITY COORDINATED THE CONCEPTION, DESIGN, AND BUILDING IN SUCH MASTERLY FASHION AS TO PRODUCE A RECORD FOR CONSTRUCTION WORK OF THIS CLASS AND MAGNITUDE;

TO JOHN H. SKEGGS, DISTRICT ENGINEER OF THE CALIFORNIA STATE HIGHWAY COMMISSION, FOR HIS ABLE SUPERVISION OF THE DESIGN AND CONSTRUCTION OF THE BRIDGE APPROACHES;

TO CHARLES E. ANDREW, BRIDGE ENGINEER OF THE CALIFORNIA STATE HIGHWAY COMMISSION, WHOSE DIRECT SUPERVISION HAS SO GREATLY REDUCED THE TIME REQUIRED FOR CONSTRUCTION AND ERECTION;

TO GLENN B. WOODRUFF, ENGINEER OF DESIGN; AND TO RALPH A. TUDOR, SENIOR DESIGNING ENGINEER, WHOSE CAREFUL SUPERVISION OF DESIGN DETAILS CONTRIBUTED SO LARGELY TO THE FINAL SUCCESS OF THE PROJECT.

AMERICAN SOCIETY CIVIL ENGINEERS

Walter L. Huber, Chairman — [illegible], Secretary

AMERICAN INSTITUTE ELECTRICAL ENGINEERS

H. S. Lane, Chairman — F. S. Benson, Secretary

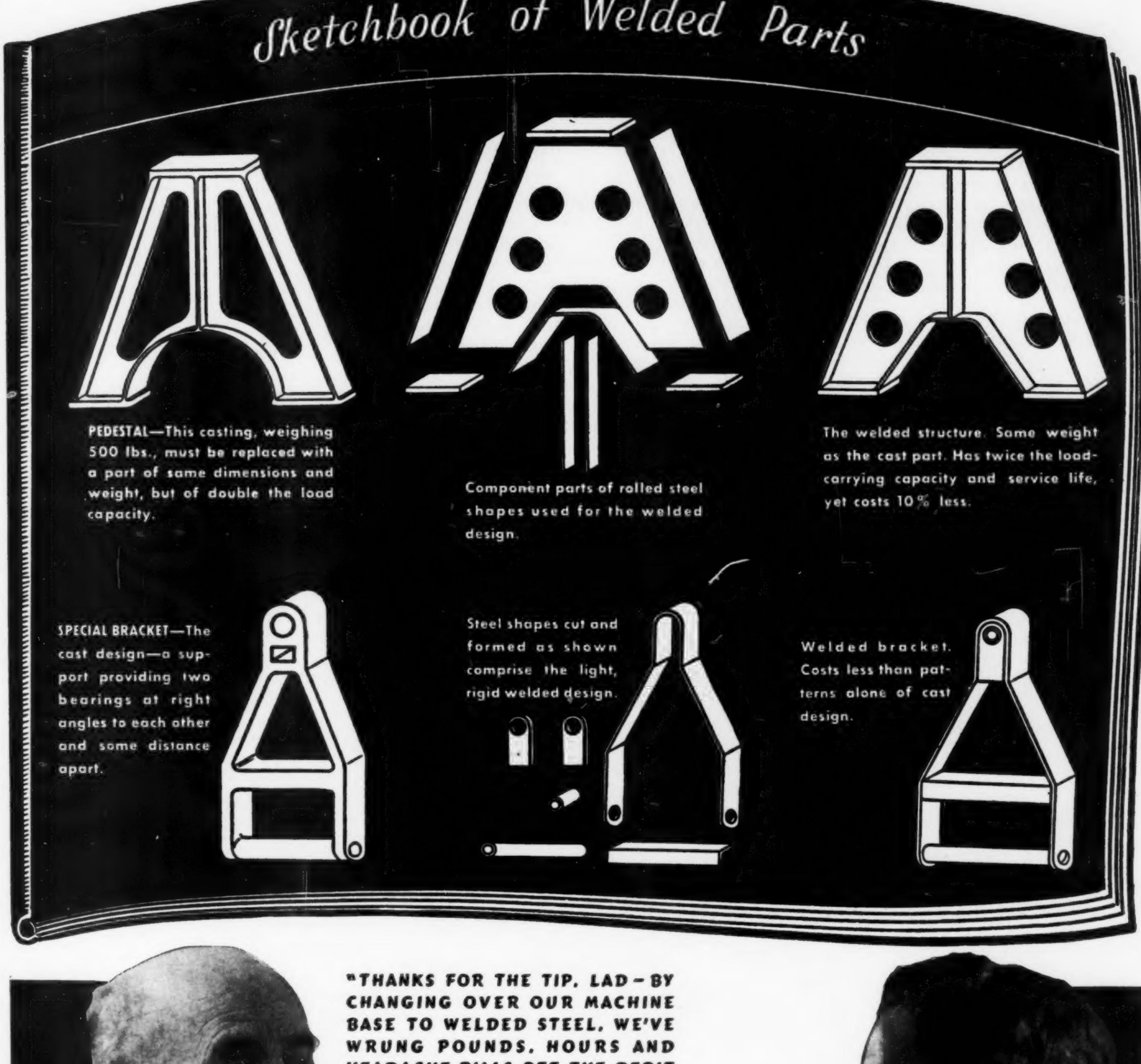
AMERICAN INSTITUTE MINING AND METALLURGICAL ENGINEERS

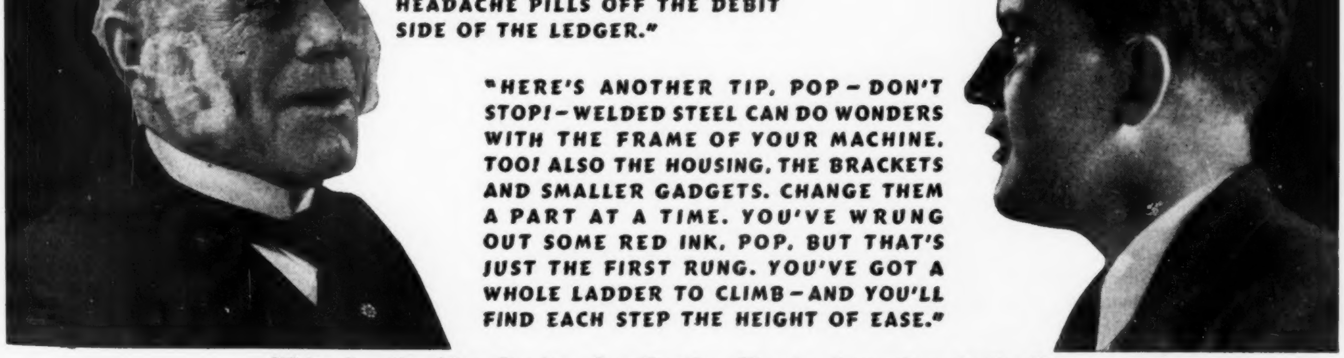
[illegible], Chairman — Herbert A. Sawin, Secretary

AMERICAN SOCIETY MECHANICAL ENGINEERS

Olive B. Lyman, Chairman — [illegible], Secretary

SCROLL OF APPRECIATION PRESENTED BY SAN FRANCISCO ENGINEERS





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DEVELOPMENT ENGINEER, mechanical, 35–40, with considerable practical shop experience, particularly in machine tools. Manufacturing experience would be helpful. To act as assistant in charge of development, design, and building of special machinery, and to follow through in getting machinery into production. Must have good personality and be able to work with men in shop. Salary, $4000–$5000 a year. Apply by letter. Location, New England. Y-1128.

MECHANICAL ENGINEER for sales work. Must have experience in steam and combustion. Salary, $5000–$7000 a year. Apply by letter. Location, New York, N. Y. Y-1186.

MECHANICAL ENGINEER, 25–30. Must be engineering-college graduate or equivalent, and must have thorough knowledge of basic principles of engineering and machine design. Energetic man with both practical and design experience preferred. Should be sales-minded, although extensive sales experience is not necessary. At first will assist sales engineer and follow up existing contracts, but later should be able to cover extensive mid-western territory himself, developing sales for product requiring considerable amount of application engineering. Salary plus traveling expenses. Apply by letter. Headquarters, Middle West. Y-1215C.

FACTORY SUPERINTENDENT for a company manufacturing builders, hardware, bolts, etc. Must have experience in stamping. Salary $6000–$7500. Location, Pennsylvania. Y-1236.

Local Sections

Coming Meetings

Anthracite-Lehigh Valley: April 23. Dinner at 6:30 and Section meeting at 8:00 p.m. in Allentown, Pa. (hotel to be announced later). The subject will be "History of Mechanical Engineering in the Allentown Area" and well-known engineers will speak on the history of the following industries: Zinc, slate, lime, cement, automotive, heavy machinery, conveying machinery. The program will be devoted to the mechanical element only and to those men who conceived, invented, and developed the mechanical equipment in these various industries.

Cleveland: April 7. The April meeting with Prof. A. G. Christie of Johns Hopkins University, as guest speaker, promises to be exceptionally interesting as the speaker is a national authority on power-plant practice with experience in the field dating back to the early days of turbines as prime movers.

North Texas: April 5. Dinner Meeting at 6:30 p.m. at Hensley Field Airport, Grand Prairie, Texas. Subject: "Military Aviation," by Major H. S. Thompson, Commanding Officer, Hensley Field, U. S. Army Air Corps.

Schenectady: April 8. Union College Chapel at 8:00 p.m. Subject: "Economic and Engineering Progress," by Professor Moulton, Brookings Institute.

Tri-Cities: April 26. Meeting to be held in the United Light & Power Co. Auditorium, Davenport, Iowa. Subject: " 'Emergencies' in Operating a Large Steam-Electric Plant," by Alex D. Bailey, chief operating engineer, Commonwealth Edison Co., Chicago, Ill.

Washington, D. C.: April 8. University of Maryland, College Park, Md., at 8:00 p.m. Meeting under the joint auspices of the Washington, D. C., and Baltimore Sections of the A.S.M.E. Subject: "The National Geographic Stratosphere Flight," by Dr. Lyman J. Briggs, Director of the National Bureau of Standards, Washington, D. C.

Necrology

THE following deaths of members have recently been reported to the office of the Society:

BOER, WESTINUS, February 16, 1937
CHURCHILL, WILLIAM L., March 8, 1937
MARUM, OTTO, February 17, 1937
OHMES, ARTHUR K., February, 1937
SCHEFFLER, FREDERICK A., February, 23, 1937
STEWART, GEORGE G., January 14, 1937
THOMSON, ELIHU, March 13, 1937
VOY, E. L., February 26, 1937

A.S.M.E. Transactions for March, 1937

THE March, 1937, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics,* contains the following papers:

TECHNICAL PAPERS

- Bending of an Infinite Beam on an Elastic Foundation, by M. A. Biot
- Cantilever Plate With Concentrated Edge Load, by D. L. Holl
- Stresses in Symmetrically Loaded Hemispherical Shells Having Tapered Edges, by S. C. Hollister
- An Electrical-Resistance Method of Determining the Mean Surface Temperature of Tubes, by J. H. Marchant
- Design of Members Subjected to Creep at High Temperatures, by J. Marin
- The Torsionless Bending of a Hollow Beam by a Transverse Load, by W. L. Schwalbe

RESEARCH REVIEW

- Recent Research Work in Lubrication, by G. B. Karelitz

DESIGN DATA

- Thermal Stress, by J. N. Goodier

DISCUSSION

- On previously published papers by O. J. Horger and J. L. Maulbetsch; and M. M. Frocht

BOOK REVIEWS

- By E. S. Dennison; J. A. Goff; J. Ormondroyd; G. B. Karelitz; L. S. Jacobsen; F. Bitter; J. P. Den Hartog; I. F. Morrison; and P. M. Morse

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after April 26, 1937, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of the A.S.M.E. at once.

NEW APPLICATIONS

BAUM, EDWIN P., Birmingham, Ala.
BECHAUD, LESLIE J., Berkeley, Calif.
BENJAMIN, WINFIELD ERVIN, JR., East Falls, Philadelphia, Pa.
BIESHELT, OSCAR, Alliance, Ohio
BOLZ, HAROLD A., Shaker Heights, Ohio (Re)
BOWEN, GEORGE W., Whittier, Calif.
BROWNSTEIN, HAROLD, New York, N. Y.
CHRISTOFFERSEN, WM. L., Ozone Park, L. I., N. Y.
COWIE, ALEX., Minneapolis, Minn.
DANZIGER, MAX J., New York, N. Y.
DARLING, F. E., Jackson Heights, L. I., N. Y. (Rt & T)
DAVIS, ELIOT R., Montreal, Que., Can.
DUFF, JAMES A., Scarsdale, N. Y.
DUMOND, LOYD P., Croswell, Mich.
FERMIER, GEORGE F., Houston, Tex.
GOLBER, HYMAN ELI, Chicago, Ill.
GORNEY, EDWARD A., Taylor, Pa.
GUTHRIE, GEORGE G., Detroit, Mich.
HADLEY, ROBERT C., Beloit, Kan.
HODER, FRANK J., JR., Germantown, Pa. (Re)
KRAMER, ALEXANDER E., San Francisco, Calif.
LATHAM, ROBERT H., JR., California, Mo.
LEE, EVERETT S., Schenectady, N. Y.
MCCUTCHEON, JOHN M., New York, N. Y.
MARBURG, L. HELLMUTH, Montclair, N. J.
MUGFOR, R. J., Toledo, Ohio
NELSON, CARL W., Canton, Ohio
PEYREBRUNE, HENRI E., Chicago, Ill.
REED, C. A., Washington, D. C.
RICHARDSON, JAMES K., Denver, Colo.
SCHACHER, ADALBERT M., Brooklyn, N. Y.
SCHENK, J. M., Prospect Park, Pa.
SHANNON, W. B., North Harrow, Middlesex, England
SINK, PROF. R. S., Laramie, Wyo.
SITES, BENJAMIN L., Chicago, Ill.
THOMSEN, ERICH G., Saulsalito, Calif.
WEISBERG, HERMAN, Maplewood, N. J.

CHANGE OF GRADING

Transfers from Junior

HANSEN, ALF, Denver, Colo.
LEVERING, WILLIAM C., Union, N. J.
OTTE, KARL H., Chicago, Ill.